REPORT NO. RL-TR-72-4

FIELD INVESTIGATION OF GUNNER AIMING ERROR AS A FUNCTION OF LAUNCHER WEIGHT

by
Gerald Chaikin, John Chipser,
and Nancy Rich

February 1972

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U.S. ARMY MISSILE COMMAND
Redstone Arsenal, Alabama

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13. ABSTRACT

This report presents a field investigation of aiming error as a function of launcher weight and tracking rate for manportable air defense system applications. The effects of launcher weights of 30, 35, 40, 45 and 50 pounds, and tracking rates of below 1, 1 to 4, 4 to 7, and above 7 degrees/second are examined in terms of aiming error at the point of uncage.

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FOREWORD

Field tests cannot be conducted without the cooperation of many people. This is particularly true of tests, such as those described in this report, which are "piggy-backed" onto already planned field work, requiring considerable tolerance and additional effort from "parent test" personnel. Cooperation and support were received from so many people that the writers must apologize for inadvertent omission of deserving acknowledgments.

The writers would like to thank Major W. M. Harborth, U.S. Marine Corps Liaison Officer, U.S. Army Missile Command (USAMICOM), and Mr. Dennis Vaughn, REDEYE II Project Office, USAMICOM, for coordinating the effort with other agencies and for securing critical test materials and instrumentation. Mr. Claude McCain, U.S. Army Human Engineering Laboratories (HEL), and Dr. Al Carver, Braddock, Dunn and McDonald, Inc., were immensely helpful in test planning, particularly in the areas of experimental design, test subject briefing, and gunner-observer task structure. Mr. Milton Krone, U. S. Army Air Defense School (USAADS), arranged for use of qualified REDEYE gunners as test subjects. Mr. Kirt Brinkley and Mr. Robert Gschwind, HEL, performed reduction, tabulation, and preliminary evaluation of the data. The writers are also grateful to Mr. Don Hendrix, Night Vision Laboratories, for on-site photographic processing support and Mr. Bill Hill, General Dynamics, who furnished the close-up photography appearing in this report. Special thanks are due Mr. Dave Salonimer and Mr. Lonny Looger, Directorate for Research, Development, Engineering and Missile Systems Laboratory, (DRDE&MSL), USAMICOM, who respectively furnished and modified the experimental tracker.

The efforts of the following individuals who served as test monitors, are also appreciated: CW4 Jack Coffelt, U.S. Army Combat Developments Command Air Defense Agency, who also assisted in test subject indoctrination and briefing sessions; Mr. Dean Reese, DRDE&MSL, who also assisted with the flight profile analysis during test planning; Lt. Frederick Roberts, USAADS; and LT David Scanlon, Yuma Proving Ground.

Finally, the writers are indebted to CPT Gene O'Neill and CPT Gerry German, U.S. Marine Corps Development and Education Center, who were responsible for technical and administrative management of the LADS II/AMTOC II test and into whose capable hands all problems descended. Their energetic cooperation enabled the test to be performed in an expedient and effective manner.

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1. Introduction

a. Background and General Objective

The requirement for this investigation was established as a result of the REDEYE II System Development Plan in process review (IPR), convened 18 and 19 August 1971 at the U.S. Army Missile Command (MICOM), Redstone Arsenal, Alabama. Development of REDEYE II will probably require a weapon weight somewhat higher than that of REDEYE as a consequence of upgraded system capabilities and potential use of such launcher-mounted ancillary equipment as identification friend or foe (IFF) and night vision (NV) components. Pursuant to this "growth" prospect, the objective of this investigation was to determine gunner aiming error as a function of launcher weight for evaluation along with results of other investigations (e.g., fatigue, handling, portability, etc.). Launcher weight was defined as the weight of the launcher and its contents in an engagement-ready configuration.

b. Approach

To accomplish this task in an expedient and economical manner, a field test was undertaken in conjunction with the Lightweight Air Defense System/Advanced Manportable Technical and Operational Capabilities (LADS II/AMTOC II) tests conducted from 15 November to 2 December 1971 at Yuma Proving Ground, Arizona. This investigation of aiming error as a function of launcher weight, hereafter referred to as the launcher weight test, was not completely integrated into the overall LADS II/AMTOC II test plan or instrumentation, but employed the LADS II/AMTOC II high performance aircraft as targets and utilized available communication to meet specific subtest objectives.

After a REDEYE gunner completes warmup and initial target acquisition tasks, assuming a target is engagable and an acceptable acquisition signal occurs, he maintains track, and depresses the gyro uncage bar which establishes seeker reference planes. On the basis of the gunner's determining the target course as incoming, crossing left or crossing right, the weapon is slewed to place the proper lead-superelevation point on the target and the firing trigger is squeezed. For purposes of this test, the parameter of primary interest was the gunner's aiming error at uncage because it is at this point that seeker lock on is enabled as a result of gunner action. The following were specific objectives of the launcher weight test.

1) Primary - Measure gunner aiming error at uncage as a function of launcher weight and tracking rate during engagement of high performance aircraft.

2) Secondary - Obtain data on the gunner's post-uncage task--lead, superelevate and fire--as a function of launcher weight and tracking rate during engagement of high performance aircraft.

c. Constraints

(1) Weight Distribution. To keep the scope of the test within reasonable limits, a systematic evaluation of launcher weight distribution was not planned; however, balance for each launcher was fixed to correlate as closely as possible to that anticipated for the system.

(2) Handling, Portability, and Fatigue. Again, to keep the test parameters within reasonable limits, handling, portability, and fatigue factors were not integrated into the launcher weight test, but merely recorded as observations when possible.

(3) Targets and Schedule. The launcher weight test was necessarily constrained to use of the LADS II/AMTOC II targets, their flight profiles and order of presentation (Annex A), and general schedule of field operations.

(4) Test Area. Available area at which the launcher weight test could be conducted was 200 to 300 meters from ground zero (the point from which target offsets were measured).

(5) Available Tracking Rates. Flight characteristics for the LADS II/AMTOC II targets are shown in Figure 1. All aircraft flew as close as possible to a speed of 600 knots. Because aircraft profiles and speeds were controlled for the LADS II/AMTOC II flights and the launcher weight test was conducted at a fixed point close to ground zero, available tracking rates were readily determined. The relationship between tracking rate and time (or range) from crossover is contained in Annex B and graphically shown in Figure 2. Profile coding of Figure 2 is defined in the Glossary.

Since, as will be discussed later, data collection methods called for uncage-on-command, it was felt that a minimum of approximately 3 seconds would be required from target entry into a tracking rate class interval to the time it left that interval. This is above the acquisition-to-uncage time achieved with the system. A second constraint relative to use of Figure 2 to establish tracking rate class intervals was avoidance of engagement at launcher elevations above 60 degrees.

Because of the practical constraints and the suitability of using four track rate intervals (a function of achieving a balanced test matrix for 10 test subjects, 5 launchers and 80 flights), it was established that usable tracking rates must be present in more than one of the seven available profiles, each of which was to be flown 12 times. On this basis, the following categories of tracking rates were fixed for the launcher weight test: A - below 1 degree/second, B - 1 to 4 degrees/second, C - 4 to 7 degrees/second, D - above 7 degrees/second.

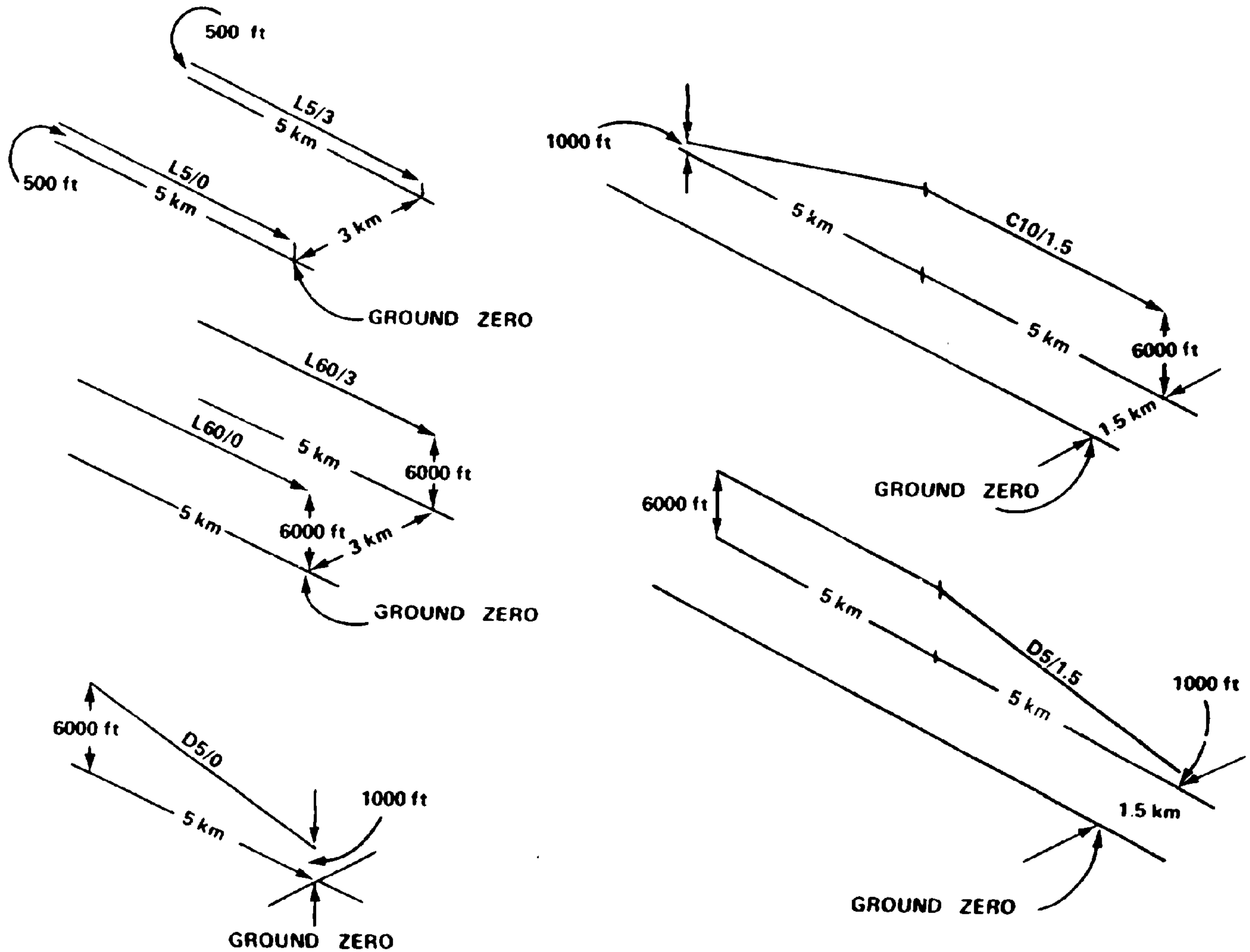

Figure 1. Flight Profiles

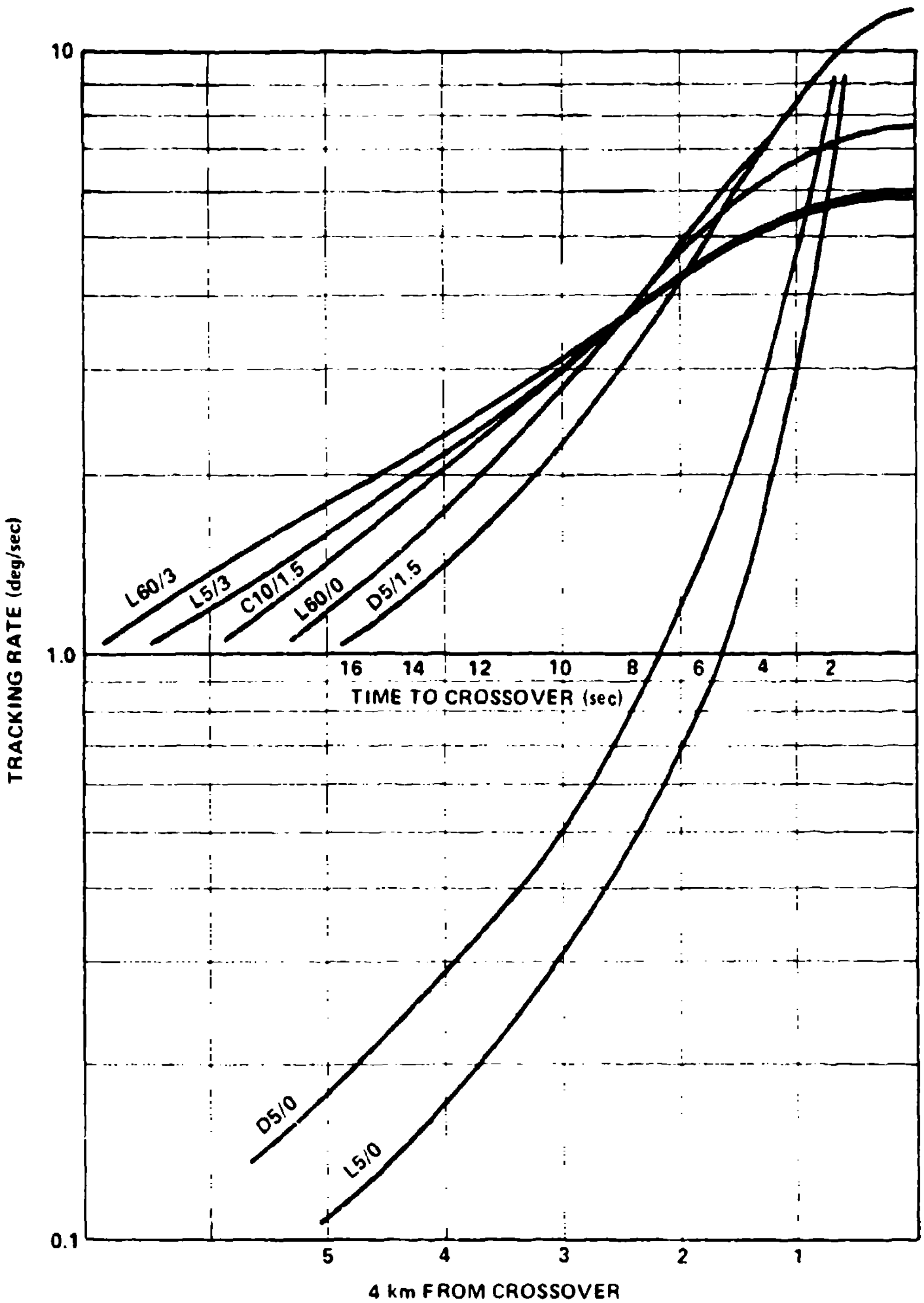

Figure 2. Tracking Rate Versus Time (Distance) to Crossover

2. Test Materiel and Instrumentation

a. Basic Test Devices

(1) Aiming Error at Uncage. Five expended launchers were modified to incorporate a TV camera mount and connection of the uncage and firing switches to a tone generator for annotation of uncage and fire events on the audio channel of the video tape. Each launcher, 60-inches long, was weighted and balanced to yield one fixed weight launcher at each of the following weights: 30, 35, 40, 45 and 50 pounds. A fixed weight launcher is shown in Figure 3.

Figure 3. Fixed Weight Launcher

To secure required precision for measuring aiming error at uncage, the fixed weight launcher cameras were equipped with lenses to give a 2-degree field-of-view (FOV). The TV cameras were boresighted to the launcher sight and were capable of being adjusted as required. Properly dimensioned reticles were provided to facilitate boresight alignment and aiming error determination. (The reticle was recorded on the video tape.) A fixed weight launcher camera and mount are shown in Figure 4.

Each TV camera was connected, via extension cable, to a recorder positioned approximately 1 foot above the ground on the launcher crate (Figure 3). Each camera was controlled from its recorder; each recorder was turned on and off by use of a switchbox on the end of a 6-foot cable (Figure 5).

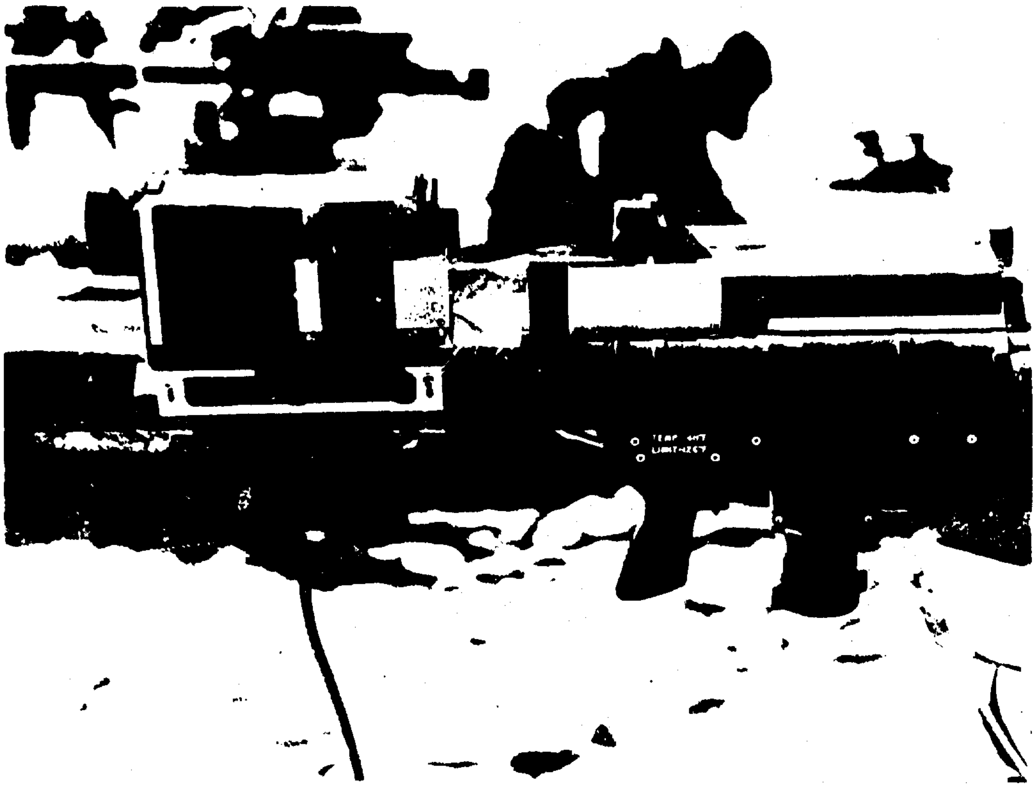

Figure 4. Fixed Weight Launcher Camera and Mount

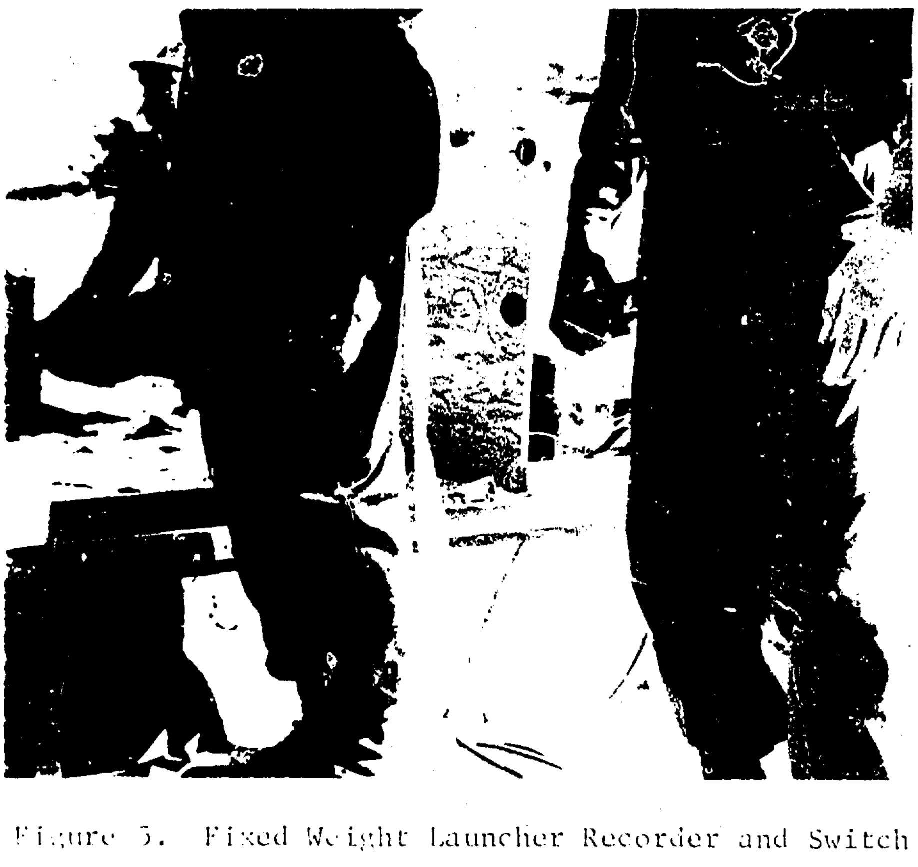

Figure 5. Fixed Weight Launcher Recorder and Switch Box

(2) Lead, Superelevate, and Fire. One expended launcher was modified to incorporate a 16mm camera mount and to provide signals (red lights visible in the FOV) from the uncage and fire switches. This launcher, 60-inches long, was capable of accepting any of five interchangeable weight packages such that the total launcher weight could be matched, as required, with those of the five fixed weight launchers. Balance for all launchers approximated that envisioned for the REDEYE II launcher. The variable weight launcher is shown in Figure 6.

Figure 6. Variable Weight Launcher

To secure film coverage of aiming error at uncage and fire and uncage-to-fire time, the variable weight launcher camera was equipped with a wide angle lens, suitably boresighted and capable of adjustment as required. A properly dimensioned reticle was provided to facilitate boresight alignment and aiming error determination. (The reticle was recorded on the film.) The variable weight launcher camera and mount are shown in Figure 7.

The 16mm camera was cabled to a ground-mounted power-supply/switch box. Method of ballast change for the variable weight launcher is shown in Figure 8.

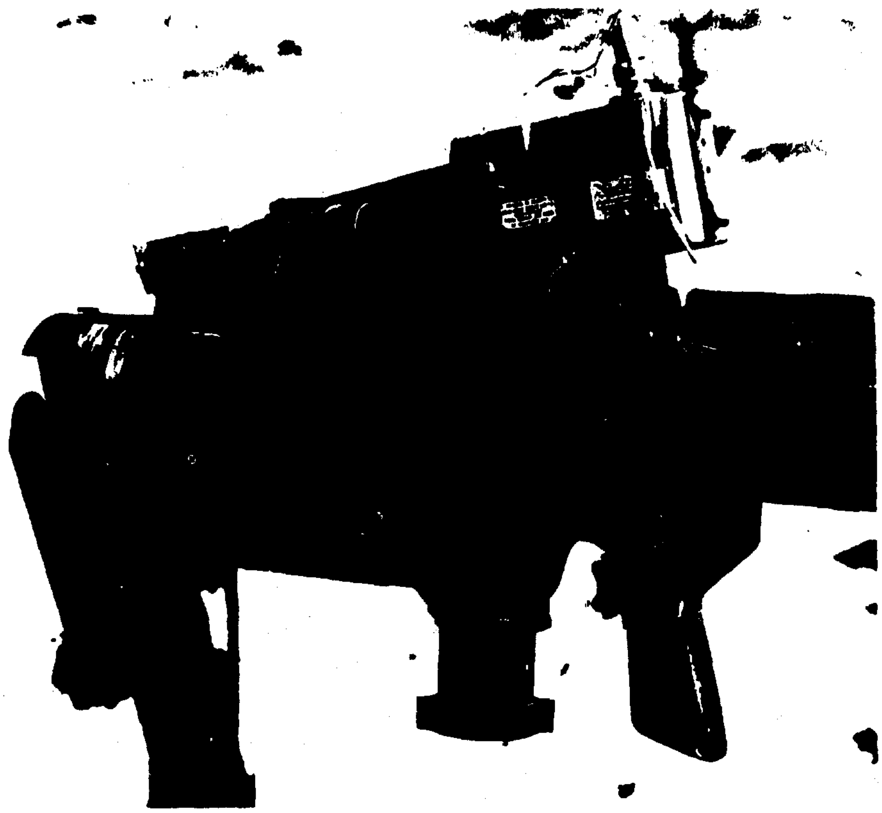

Figure 7. Variable Weight Launcher Camera and Mount

(3) Rationale. Because of the requirements and constraints previously noted, data collection by pictorial means, either photographic or video tape, appeared to offer the greatest potential simplicity. Data could be readily reduced through analysis of playback using a template or overlay to define aiming error. Video tape offered some advantage over film in terms of processing requirements, availability of an on-site record, certainty of on-site camera adjustments, immediate identification of recording problems, and use of the audio channel for event annotation.

The need for precisely defining aiming error at uncage dictated use of a narrow FOV while securing data on lead, superelevate and fire dynamics required use of a wide FOV. Use of zoom lenses to accommodate these FOV requirements were rejected in favor of test device design simplicity.

b. Tracker

An available, manually-operated, viscous-damped tracker with track rate readout was used for indicating when the desired track rates were achieved, thereby serving as a basis for giving uncage

Figure 8. Changing Variable Weight Launcher Ballast

commands. Calibration of the rate readout disclosed an output of 10 millivolts/degree/second. A four-power, wide-angle scope, usable with minimum eye relief, was installed as the tracker sight. Reticle pattern was a simple crosshair. Rate readout was obtained by use of a sensitive volt ohmmeter (VOM). The tracker is shown in Figure 9.

c. Launcher Cradles

To avoid potential camera and boresight problems, which might otherwise result from placing the launchers on the ground, the test launchers were placed in cradles when not in use. These cradles consisted of two upright slats, with semicircular cutouts on top, inserted in the shipping crates (Figures 3 and 6).

Figure 9. Tracker

d. Field Phone

A field phone was available at the test site to alert the test conductor to inbound aircraft and for callout of a 5-kilometer mark which could serve to time-correlate the video tape events to various LADS II/AMTOC II measurements should such correlation prove profitable at a later time.

e. Other

Other test devices and instrumentation such as TV playback unit, monitor, tape and film supply, forms, power supplies, bullhorn, and cabling are listed in Annex C.

3. Test Matrix and Flight Sequence

a. Aiming Error at Uncage

Ten test subjects (Paragraph 4) were divided into five teams of two each such that every subject served as a gunner for half the trials and as an observer for half the trials. The test was structured for each subject to experience each of four tracking rates at each of five launcher weights with two replications, thereby securing 400 data points using 80 flights. A matrix of these data points appears in Table I.

Table I. Subject Treatments - Aiming Error at Uncage (Fixed Weight Launchers)

Total	400																			
Weight*	VL 80				L 80				M 80				H 80				VH 80			
Track Rate**	A 20	B 20	C 20	D 20	A 20	B 20	C 20	D 20	A 20	B 20	C 20	D 20	A 20	B 20	C 20	D 20	A 20	B 20	C 20	D 20
Subjects† 1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				

*VL = 30 lb, L = 35 lb, M = 40 lb, H = 45 lb, and VH = 50 lb

**A = below 1 deg/sec, B = 1 to 4 deg/sec, C = 4 to 7 deg/sec, and D = above 7 deg/sec.

†Two replications per cell.

b. Lead, Superelevate, and Fire

A test subject from team 1/6 (composed of gunners 1 and 6) was assigned to operate the variable weight launcher during trials when he would otherwise serve as observer for a fixed weight launcher, the variable weight launcher being adjusted to match the fixed weight

launcher which his teammate operated. (Test monitors served as observers for team 1/6.) This subtest was structured for each subject to experience each of four tracking rates at each of five launcher weights with two replications, thereby securing 80 data points over 80 flights. A matrix of these data points appears in Table II.

Table II. Subject Treatments - Time from Uncage to Fire and Aiming Error at Fire (Variable Weight Launcher)

Total	80																			
Weight	VL 16				L 16				M 16				H 16				VH 16			
Track Rate	A 4	B 4	C 4	D 4	A 4	B 4	C 4	D 4	A 4	B 4	C 4	D 4	A 4	B 4	C 4	D 4	A 4	B 4	C 4	D 4
Sub- 1																				
jects 6																				

(Annotations equivalent to those of Table I)

c. <u>Flight Sequences</u>

A flight sequence was prepared so that the above treatments could be accomplished using the LADS II/AMTOC II flight schedule (Annex A) previously noted as a constraint. This sequence, presented in Table III, minimized the number of launcher changes and the number of weight changes required in the variable weight launcher, and insured that the order of weight presentation for each test subject did not reflect a consistent increase or decrease in weights experienced.

d. <u>Flight Sequence Sheets</u>

The sequence presented in Table III and the information in the LADS II/AMTOC II flight schedule (Annex A) were combined into flight sequence sheets (Annex D), showing flight number, rate, rate readout value (which will be described later), quadrant/clock direction from which the aircraft would initially appear, azimuth at which the initial aircraft maneuver would be made, characteristics of the flight profile, fixed weight launcher assignments, variable weight launcher assignment, and space for time recording and other annotations. These sheets were used for planning purposes and as an on-site aid by the test conductor and monitor personnel. Test subjects were not given access to these sheets.

Table III. Planned Flight Sequence

		Fixed Weight Launchers (TV)					Variable Weight Launcher (16mm)				
Flight	Rate	VL	L	M	H	VH	VL	L	M	H	VH
1	A	1	2	3	4	5	6				
2	B	1	2	3	4	5	6				
3	C	1	2	3	4	5	6				
4	D	1	2	3	4	5	6				
5	D	6	7	8	9	10	1				
6	A	6	7	8	9	10	1				
7	B	6	7	8	9	10	1				
8	C	6	7	8	9	10	1				
9	A	5	1	2	3	4		6			
10	A	5	1	2	3	4		6			
11	B	5	1	2	3	4		6			
12	A	10	6	7	8	9		1			
13	B	10	6	7	8	9		1			
14	C	10	6	7	8	9		1			
15	D	10	6	7	8	9		1			
16	A	10	6	7	8	9		1			
17	B	2	3	4	5	1					6
18	C	2	3	4	5	1					6
19	B	2	3	4	5	1					6
20	C	7	8	9	10	6					1
21	B	7	8	9	10	6					1
22	A	7	8	9	10	6					1
23	C	7	8	9	10	6					1
24	D	7	8	9	10	6					1
25	B	4	5	1	2	3			6		
26	A	4	5	1	2	3			6		
27	A	4	5	1	2	3			6		
28	A	9	10	6	7	8			1		
29	D	9	10	6	7	8			1		
30	C	9	10	6	7	8			1		
31	D	9	10	6	7	8			1		
32	A	9	10	6	7	8			1		

Table III. Continued

Flight	Rate	Fixed Weight Launchers (TV)					Variable Weight Launcher (16mm)				
		VL	L	M	H	VH	VL	L	M	H	VH
33	D	3	4	5	1	2				6	
34	D	3	4	5	1	2				6	
35	D	8	9	10	6	7				1	
36	A	8	9	10	6	7				1	
37	A	8	9	10	6	7				1	
38	B	3	4	5	1	2				6	
39	C	3	4	5	1	2				6	
40	D	8	9	10	6	7				1	
41	C	3	4	5	1	2				6	
42	A	3	4	5	1	2				6	
43	B	3	4	5	1	2				6	
44	C	8	9	10	6	7				1	
45	B	8	9	10	6	7				1	
46	B	8	9	10	6	7				1	
47	C	8	9	10	6	7				1	
48	A	3	4	5	1	2				6	
49	C	4	5	1	2	3			6		
50	A										
51	D	4	5	1	2	3			6		
52	C	4	5	1	2	3			6		
53	A										
54	D	4	5	1	2	3			6		
55	B	4	5	1	2	3			6		
56	D										
57	C	9	10	6	7	8			1		
58	B	9	10	6	7	8			1		
59	B	9	10	6	7	8			1		
60	C	2	3	4	5	1					6
61	D	2	3	4	5	1					6
62	A	2	3	4	5	1					6
63	D	2	3	4	5	1					6
64	B	7	8	9	10	6					1
65	A	2	3	4	5	1					6
66	A	7	8	9	10	6					1
67	D	7	8	9	10	6					1

Table III. Concluded

		Fixed Weight Launchers (TV)					Variable Weight Launcher (16mm)				
Flight	Rate	VL	L	M	H	VH	VL	L	M	H	VH
68	D	10	6	7	8	9		1			
69	D	5	1	2	3	4		6			
70	D	5	1	2	3	4		6			
71	C	5	1	2	3	4		6			
72	C	5	1	2	3	4		6			
73	B	5	1	2	3	4		6			
74	C	10	6	7	8	9		1			
75	B	10	6	7	8	9		1			
76	A	1	2	3	4	5	6				
77	A	1	2	3	4	5	6				
78	C	1	2	3	4	5	6				
79	C	6	7	8	9	10	1				
80	D	6	7	8	9	10	1				
81	B	6	7	8	9	10	1				
82	A	6	7	8	9	10	1				
83	B	1	2	3	4	5	6				
84	A										

e. Gunner Assignment Form

Gunner assignment forms, showing flight number, gunner number, clock, and a space for recording time-of-trial and other annotations, were given to each gunner-observer team to assist them in determining which launcher to use, which team member would serve as gunner, and the general direction from which the target would approach. A sample gunner assignment form appears as Figure 10.

GUNNER ASSIGNMENT FORM

FLIGHTS 1 - 8

Flight	Gunner	Launcher	Clock	Completion Time	Remarks
1	1	VL	10		
2	1	VL	10		
3	1	VL	2		
4	1	VL	10		
5	6	VL	2		
6	6	VL	10		
7	6	VL	2		
8	6	VL	2		

Figure 10. Example of Gunner Assignment Form

4. Test Subjects

a. General

Ten qualified REDEYE gunners served as test subjects for the launcher weight test. Nine of the gunners were furnished by U.S. Continental Army Command (USCONARC) as follows:

1) 4 - Headquarters, Second Armored Division, Fort Hood, Texas
2) 3 - Headquarters, First Infantry Division (Mech), Fort Riley, Kansas
3) 2 - Headquarters, First Cavalry Division, Fort Hood, Texas.

A tenth gunner was furnished by the U.S. Marine Corps (LADS II/AMTOC II test director).

b. Briefing

On 16 November 1971, the subjects were briefed on the purpose of the test, procedures, operation of equipment, and use of the gunner assignment form. The purpose of the test was announced as being a field validation of results obtained from research, using the moving target simulator, of the effects of weapon weight on various tasks, and that the current validation would examine only uncage through fire.

The test subjects were not given the weights of the launchers, but were told that the weights varied from a value below that of the trainer to above that of the trainer. All discussions and instructions relating to launcher weight were expressed as very light (VL), light (L), medium (M), heavy (H), and very heavy (VH).

Because launcher weights to be handled were as high as 50 pounds, the test subjects were requested to treat shouldering the launcher and replacing it in its cradle as a two-man operation (Paragraph 6). The reason for this procedure was explained in terms of fragility of the cameras, maintenance of boresight through gentle handling, and extreme care to avoid problems caused by dust, shock, etc.

An outline of the test subject briefing and practice sessions is presented in Annex E.

c. Team Assignments

During the initial part of the briefing each test subject was given a number and gunner-observer team assignment. These assignments and grade, age, height, and weight of each test subject are presented in Table IV.

Table IV. Test Subjects

Assignment	Grade	Age (yrs)	Height (in)	Weight (lb)
1	CPL	20	68	170
6	E3	21	70	160
2	E5	27	72	198
7	E4	23	66	150
3	E3	20	69	150
8	E6	31	70	190
4	E4	20	68	165
9	E4	20	74	165
5	E5	24	68	135
10	E4	19	69	160

d. Vision Tests

On 17 November 1971, each subject was given an orthorater test by the Yuma Proving Ground Post Hospital. Subjects 4 and 9 wore corrective lenses; subject 5 wore glasses irregularly. Color deficiency was reported for subject 10.

e. Garments

Test subjects wore standard battle dress, including steel helmet and flak jacket. The field jacket was worn only in the early morning when temperatures were low and was usually discarded by the time trials began.

f. Field Practice and Shakedown Test

On 18 November 1971, a shakedown test was conducted on-site against helicopter targets to insure that all test equipment functioned properly, that the data were suitable for reduction, that the test site and operating procedures were compatible with objectives and with the LADS II/AMTOC II routines, and that the test subjects were proficient in test site procedures. The field practice sessions and shakedown test were conducted simultaneously in accordance with Annex F.

Several changes in procedure were made as a result of the first half-hour of the shakedown test, including placement of the flight marker board in a permanent location downrange from the cradled launchers, improvement of terminology used for commands, timing of the "Record!" command as a function of camera warmup, improved annotation methods, use of the test subjects for boresight checks and placement of recorders atop

the launcher shipping crates for dust avoidance and convenience of operation. The procedures of Paragraph 6 contain these changes.

During the morning of 22 November 1971, the modified procedures, previously mentioned, were used during a pretest practice session employing high performance jet aircraft as targets. No problems were encountered.

5. Description of Test Site

a. Locale

The test was conducted from 22 through 30 November 1971 at the King of Arizona (KOFA) Range, located approximately 35 miles northeast of Yuma Proving Ground, Arizona. The test area (Figure 11) was located near the center of King Valley which has an average elevation of approximately 1200 feet above sea level and is surrounded by mountains ranging from 2500 to 4200 feet in elevation. Foliation characteristics included desert type shrubbery, mesquite, and cacti.

b. Test Site and Terrain

The test site was located on a flat and level circular clearing, approximately 50 meters in diameter and approximately 240 meters north of ground zero--the point over which the zero offset trials were flown and the point from which the offsets were determined (Figure 12). The terrain surface was dry and powdery, similar to the consistency of flour after subjected to personnel traffic; however, it offered a solid footing. Small, 1- to 2-foot high desert shrub surrounded the perimeter of the test site and continued to the mountains. These shrubs were interspersed with larger, 3- to 8-foot high trees and 20-foot high cacti starting from approximately 500 meters out. Easterly and westerly views from the test site are shown in Figures 13 and 14, respectively.

c. Equipment and Personnel Deployment

(1) Launchers/Launcher Cradles. Six launchers and launcher cradles were positioned parallel to one another, facing west, along an arc running in a north-south direction (Figure 12). The launchers were placed approximately 4-meters apart with the midpoint between the third and fourth launcher positions located at the center of the test site. Launcher emplacements are shown in Figure 15.

(2) Tracker. The tracker was located on a line perpendicular to the launcher positions and approximately 7- meters east of the test site center. Tracker emplacement is shown in Figure 16.

(3) Test Conductor Position. The test conductor position, field phone, and rate indicator were located approximately 2-meters northeast of the tracker.

(4) Test Monitor Positions

a) At tracker

b) At variable weight launcher

c) At fixed weight launcher to which team 1/6 was assigned.

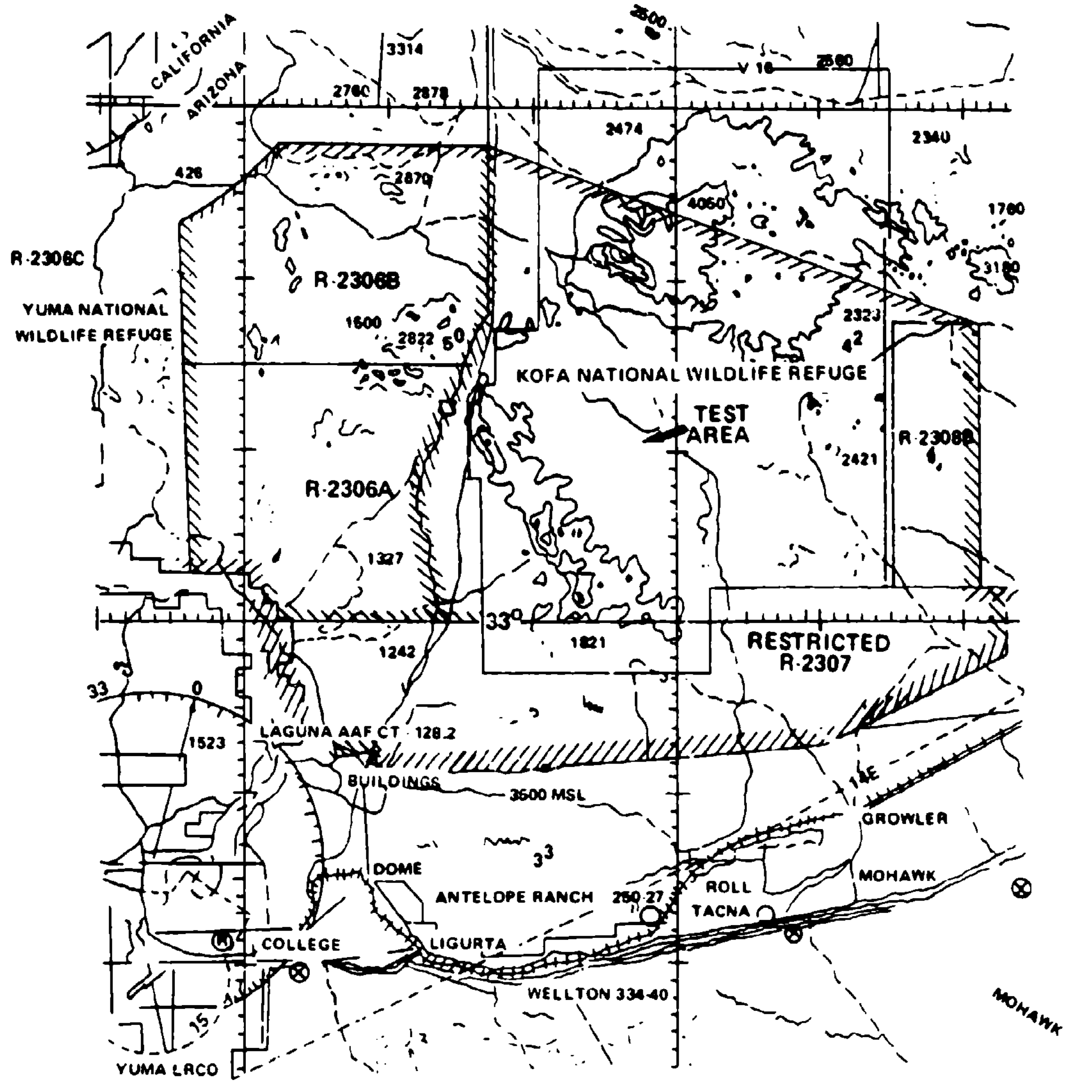

Figure 11. Test Locale

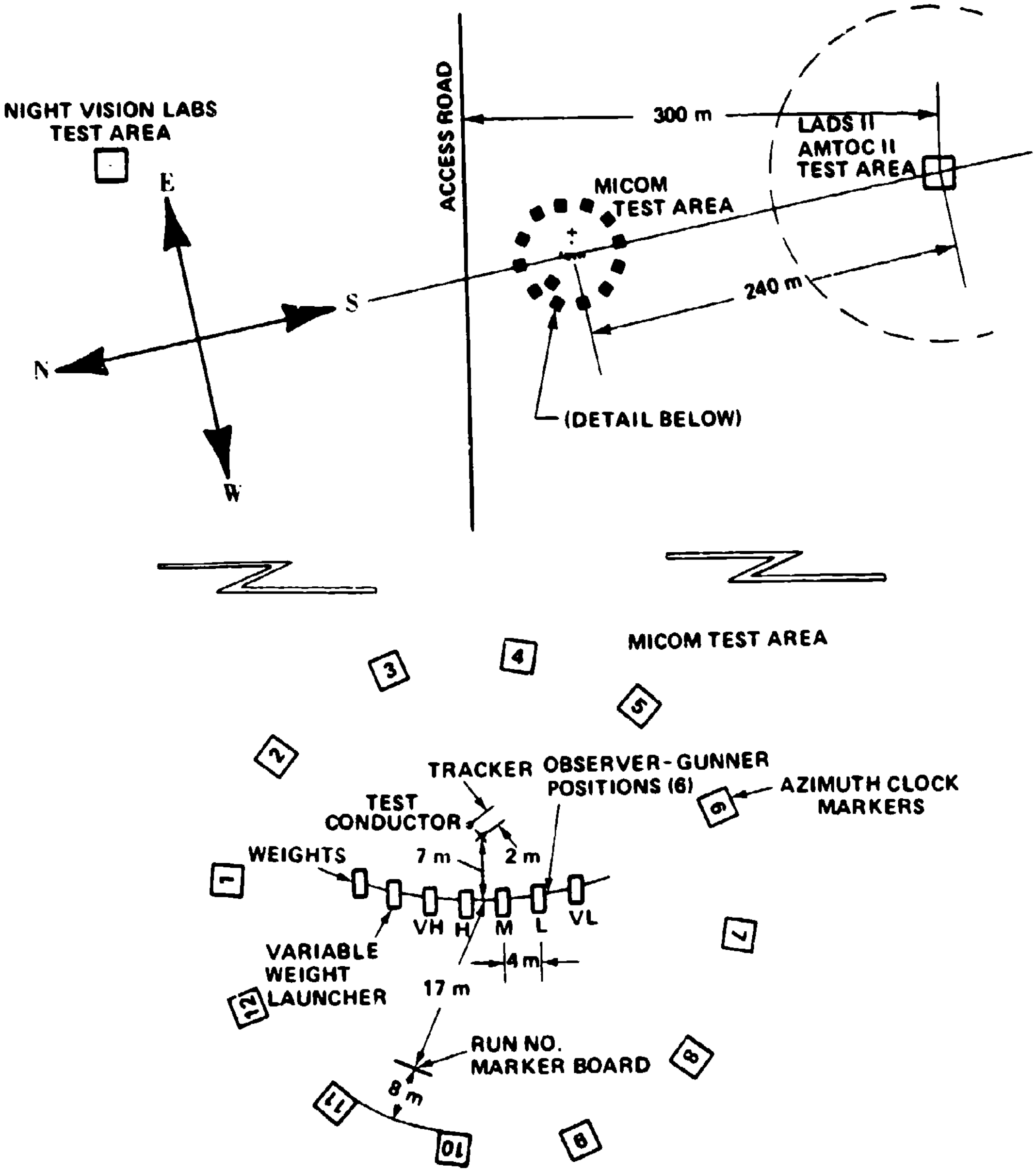

Figure 12. Test Site and Equipment Deployment

Figure 13. Terrain East of Test Site

Figure 14. Terrain West of Test Site

Figure 15. Launcher Emplacements (View to South of Test Site)

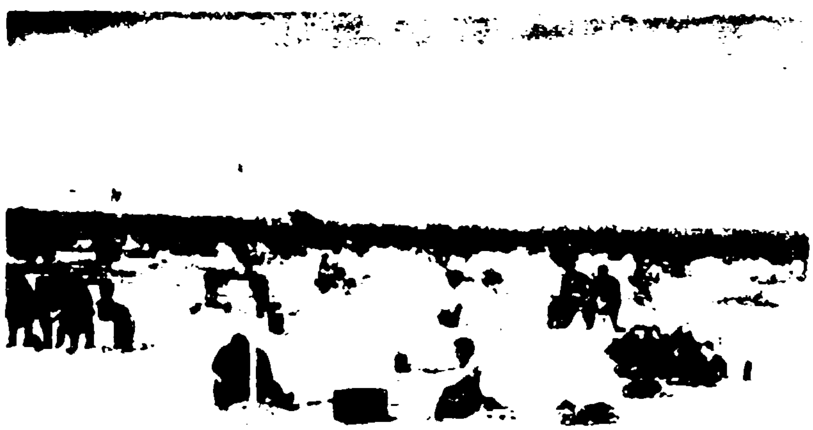

Figure 16. Tracker Emplacement (View to North of Test Site)

(5) Clock Markers. Clock marker boards (14 by 18 inches) were attached to stakes driven at 30-degree intervals around a circle of 25 meters radius measured from the test site center. Black on white clock numbers, 1-foot high, were painted on the marker boards. The 7 and 12 o'clock markers are shown in Figures 15 and 16, respectively.

(6) Flight Number Board. A 14- by 18-inch board, used for displaying the flight numbers, was located at a point 17 meters from the test site center, between the 10 and 11 o'clock markers. Red on white numerals, 1-foot high, were painted on separate cards to be attached to the board before each run.

6. Test Procedures

a. Test Personnel

For purposes of clarity in subsequent descriptions of tasks/routines, test personnel are defined as follows:

(1) Gunner - The member of the gunner-observer team who operated the launcher (the test subject).

(2) Observer - The member of the gunner-observer team who was not serving as a test subject for a particular trial, but who assisted the gunner as specified.

(3) Test Conductor - The individual responsible for maintaining contact, by field phone, with the LADS II/AMTOC II test director and radar, for receiving flight sequence and inbound aircraft data, and for giving verbal commands to the test subjects during the experimental trials.

(4) Test Monitors - Three site personnel performed the following duties:

a) Tracker Operator and Test Director - Operated the tracker and exercised general surveillance over the test site

b) Variable Weight Launcher Monitor - Served as observer for team 1/6 member operating the variable weight launcher and placed appropriate flight number markers on flight board.

c) Fixed Weight Launcher Monitor - Served as observer for team 1/6 member operating a fixed weight launcher and, using 10 X 50 binoculars, assisted all site members in target detection.

(5) Launcher Maintainer - Individual responsible for maintenance of the test launchers, to include loading and unloading film and video tapes and performing camera adjustments.

b. Initialization

At the start of each day's trials, the following tasks were performed as required:

(1) Gunners and Observers

a) Affix clock markers to azimuth stakes

b) Set up each launcher and its associated cabling

c) Review gunner assignment forms (see Figure 10 for example) and perform dry runs if desired

d) Insert proper weight in variable weight launcher

e) Check boresight and notify launcher maintainer if adjustments are required.

(2) Launcher Maintainer

a) Check each launcher, power supply, cable assembly, etc., and insure proper operation of cameras

b) Check video tape and film supply and examine each camera to insure that tape and film supply is adequate for next segment of trials. Reload cameras as required, mark each removed tape and film with data and launcher number, and adjust boresight as required.

(3) Test Conductor

a) Set up tracker, switch box, and VOM; checkout

b) Hook up field phone and check for proper operation

c) Time check.

(4) Test Monitors

a) Distribute gunner assignment forms, clipboards, supplies, etc., to test subjects and confirm gunner-observers at proper launchers

b) Confirm completion of launcher maintainer tasks

c) Check azimuth stakes to insure that appropriate clock markers are affixed

d) Verbally annotate each tape with date and launcher designation.

c. Experimental Trials

(1) Launcher Assignment. Consulting the gunner assignment form, the gunner and observer determine the launcher to be used for the following trial and report to the appropriate launcher position. Ballast of the variable weight launcher is changed as required.

(2) Gunner Assignment. Consulting the gunner assignment form, each team determines which member serves as the gunner and which member serves as observer for the following trial. (Rotation is not required for each trial.)

(3) Flight Number Placement. During this period, a test monitor will have removed the number of the previous trial from the flight number board and placed a new number for the next trial.

(4) Determine Inbound Approach Path. Consulting the gunner assignment form, the gunners and observers determine the clock number from which the next target will come.

(5) Search and Acquisition. Upon receipt of a 15- to 20-kilometer mark via the field phone, the test conductor announces "Inbound and Power On!" The observers turn on the cameras. The gunners shoulder their launchers, assisted by the observers. All personnel search for the target. Upon receipt of a 15-kilometer mark via the field phone, the test conductor announces "Record!", signalling the observers to turn on the recorders. When the tracker operator (test monitor) acquires the target, he initiates track. When the gunners acquire the target, they initiate track. Upon receipt of a 5-kilometer mark via the field phone, the test conductor announces "Mark!" which is recorded on the audio channels.

(6) Engagement. When the tracker VOM reaches the required rate indication, the test conductor announces "Uncage!". Upon hearing the command, each gunner uncages, leads, superelevates, fires, and returns to boresight for resumed tracking. Upon uncage, the observer raises his hand to notify the test conductor that the event is complete, then lowers his hand upon acknowledgment by the test conductor. The test conductor announces "Cease Track!" when the target has passed crossover, when it has reached a point where launcher elevation exceeds 60 degrees, when the tracking rate interval is exceeded, or when tracking across the sun is imminent. The test conductor notes VOM voltage at last uncage.

(7) Completion. At completion of the trial, noted by the "Cease Track!" command, the gunner slews to the flight number board, tapes or films the flight number and announces "Gunner ___, Flight ___." The observer turns off the recorder and camera, and the launcher is returned to its cradle. The observer and gunner record the time on the gunner assignment form along with any remarks, particularly those which would be helpful in identifying problems which would cause a run to be missed.

The general sequence is shown graphically by Figure 17.

d. Recorded Tracking and Annotation Data

Tracking data and annotations on the video tape and film, using procedures previously described are presented in Table V.

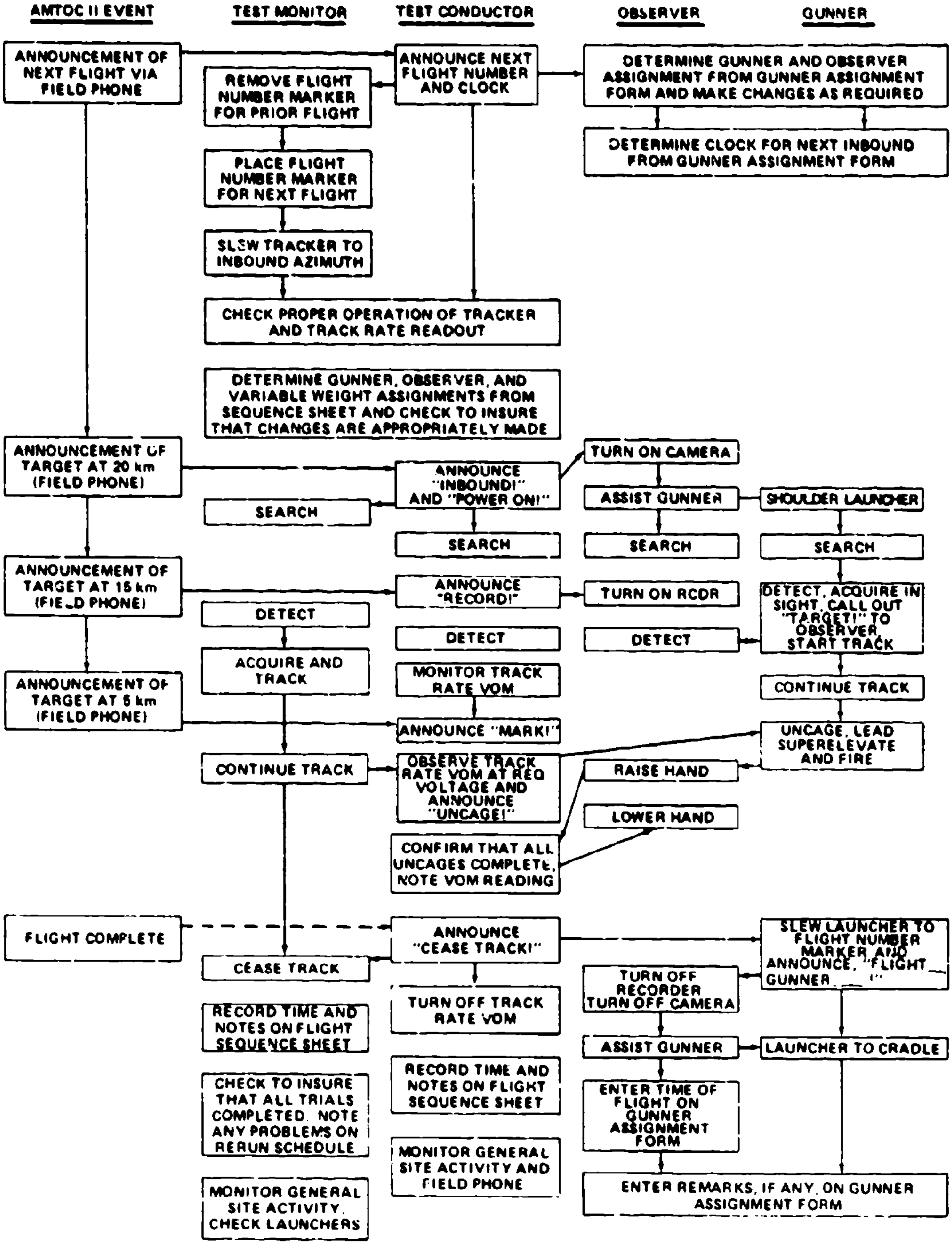

Figure 17. Site Procedures

Table V. Recorded Tracking and Annotation

Fixed Weight Launchers			Variable Weight Launcher	
Target Tracking Data (TV)	Annotation	Event	Annotation	Target Tracking Data (Film)
		"Inbound and Power On!" announced		
		"Record!" announced		
	Audio	"Mark!" announced		
	Audio	"Uncage!" announced		
	Tone on (audio)	Uncage	Lights on	
	Tone on (audio)	Lead/SE	Lights on	
	Tone off (Audio)	Fire	Lights off	
		Resume Track		
		"Cease Track!" announced		
	Video and Audio	Post-Trial Annotation	Filmed	
	*	Recorders and Camera off	*	

*Time of trial completion and remarks noted on gunner assignment form (by gunner/observer) and on flight sequence sheet (by test conductor/monitor)

7. Data Collection

a. General

The field test was conducted at the KOFA Range from 22 through 30 November 1971 at the test site described in Paragraph 5.

b. Flight Sequence

As a result of aircraft availability, fuel management requirements and related factors, it was necessary for the LADS II/AMTOC II test personnel to modify the planned test sequence. Actual flight order, correlated to the flight sequence sheet (Annex A), is presented in Table VI. Targets, therefore, appeared in a relatively random order, requiring frequent launcher changes for each team, frequent gunner-observer rotation, and frequent weight change in the variable weight launcher. No procedural problems resulted, however, because typical time between flights approximated 10 minutes and the test subjects were well versed in use of the gunner assignment form.

Trials in which targets were not acquired or in which other problems were encountered (e.g., weak batteries, tape run-out, broken switch box wires, etc.) were rerun.

c. Boresight

The test subjects were familiarized with boresight inspection procedure and checked boresight on a daily basis. Most of these boresight checks were confirmed by the launcher maintainer and test monitors. Alignment between the cameras and sights was maintained accurately through most of the test with the exception of launcher VH. Observed boresight errors were recorded on tape for appropriate corrections during data reduction.

d. Meteorological Data

Visibility during the data collection period ranged from 10 to 25 miles. Sky conditions were clear for most of the trials. Wind speed ranged from calm to 9 knots with the majority of trials being conducted in wind speeds less than 5 knots. An hourly summary of meteorological conditions experienced during the testing period, collected by the U.S. Army meteorological team, Yuma, appears as Annex C.

Table VI. Actual Flight Sequence Versus Planned Flight Sequence

22 Nov 71		23 Nov 71		24 Nov 71		29 Nov 71		30 Nov 71	
Tape Order	Flight No.	Tape Order	Flight No.	Tape Order	Flight No.	Tape Order	Flight No.	Tape Order	Flight No.
1	1	26	7	60	82	78	55	86	67
2	2	27	27	61	81	79	31	87	32VL
3	3	28	23	62	62	80	29		32VH
4	5	29	30	63	59	81	27	88	57VL
5	6	30	28	64	27	82	40VL		23H
6	9	31	25	65	25		40L	89	20
7	22	32	40	66	35		70H	90	31VL
8	10	33	43	67	16VL		70VH	91	93
9	19	34	47		27H	83	32	92	64
10	12	35	44		65VH	84	67	93	41
11	14	36	13	68	80	85	43	94	79
12	17	37	48	69	77			95	52
13	16	38	54	70	64VH*			96	49VL
14	4	39	57		43VH			97	39
15	7	40	16		75H				
16	8	41	49	71	76				
17	11	42	58	72	38				
18	21	43	65	73	71				
19	37	44	68	74	78				
20	15	45	61	75	45				
21	18	46	63	76	36A				
22	26	47	74	77	3				
23	24	48	75						
24	36	49	60						
25	51	50	69						
		51	39						
		52	34						
		53	73						
		54	72						
		55	70						
		56	46						
		57	33						
		58	42						
		59	66						

*Denotes variable weight launcher (rerun).

8. Results

a. Aiming Error at Uncage

(1) General. At the conclusion of the tests, all video tapes were delivered to the Human Engineering Laboratories, Aberdeen Research and Development Center, Aberdeen Proving Ground, Maryland, for independent data reduction, tabulation, and preliminary evaluation.

(2) Data Reduction. Aiming errors, in mils, were measured in X and Y coordinates, boresight corrections were applied in accordance with taped boresight presentations, and results converted into radial aiming error. The instant of uncage was determined from the uncage bar click (followed by the tone) in each case. Target size, in mils, at uncage was also recorded. From a possible 400 data points, 349 were recorded. Missing data resulted from conditions arising during trials which could not be rerun. On one or two occasions, the test subjects tracked commercial aircraft or other target aircraft in the area which were in the same general direction as the inbound target. Some data were lost as a result of weak batteries and tape runout. Most of the missing data, however, resulted from recorder control box wire breakage.

(3) Results. Radial aiming errors at uncage are tabulated in Annex H. Mean radial aiming error at uncage as a function of launcher weight and tracking rate is graphically summarized in Figures 18 and 19, respectively.

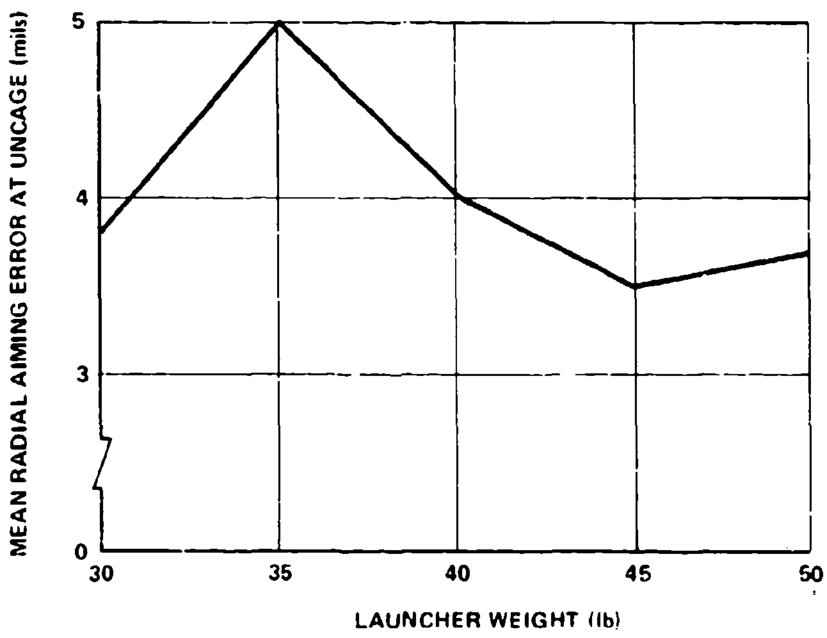

Figure 18. Aiming Error at Uncage Versus Launcher Weight

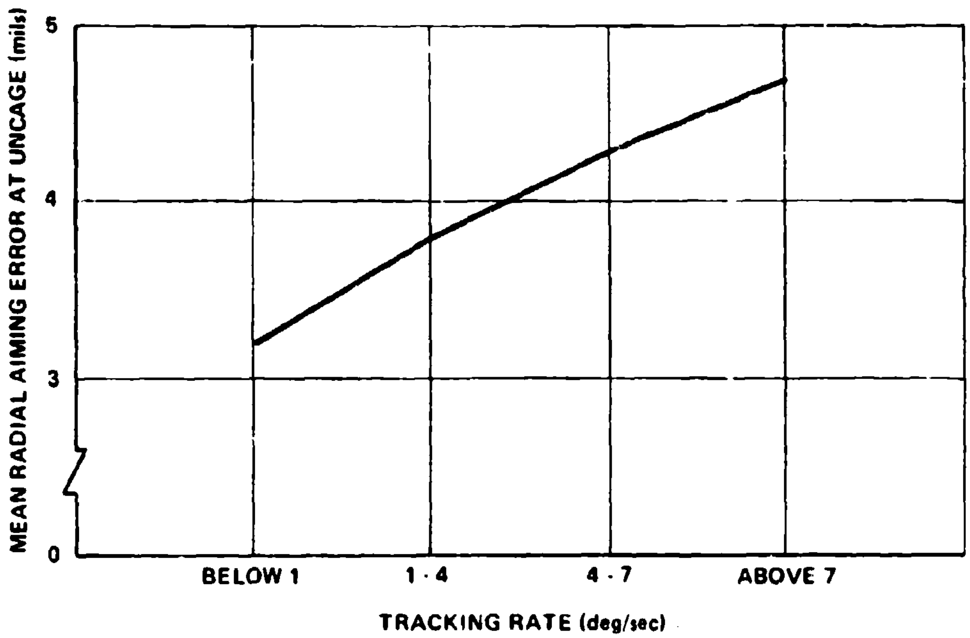

Figure 19. Aiming Error at Uncage Versus Tracking Rate

b. Lead, Superelevate, and Fire

(1) General. Film from the variable weight launcher was analyzed to determine the effects of launcher weight on time from uncage to fire and aiming error at fire.

(2) Data Reduction. Time from uncage to fire was measured by counting the number of frames during which the uncage-actuated and fire trigger-extinguished lights were on and correlating this to frame rate. Aiming error at fire was measured from the center of the aircraft to the proper superelevate point on the superimposed reticle.

(3) Results. Time from uncage to fire is tabulated in Annex I and graphically presented as a function of launcher weight in Figure 20. Radial aiming errors at fire are also tabulated in Annex I and graphically presented as a function of launcher weight in Figure 21. Two data points, reflecting extremely high values resulting from procedural errors, were omitted from Figure 21.

c. Comments by the Test Subjects

At the conclusion of test operations, the subjects were given a questionnaire soliciting their comments on utilization of the launchers in terms of tracking, the uncage-lead, superelevate-fire sequence, and general handling. Results are summarized in the following paragraphs.

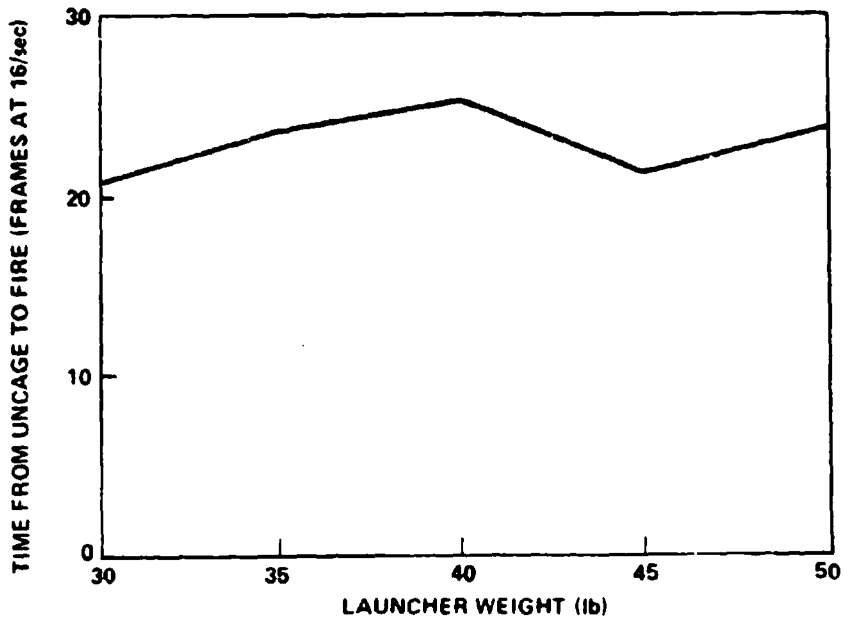

Figure 20. Time from Uncage to Fire Versus Launcher Weight (All Trials)

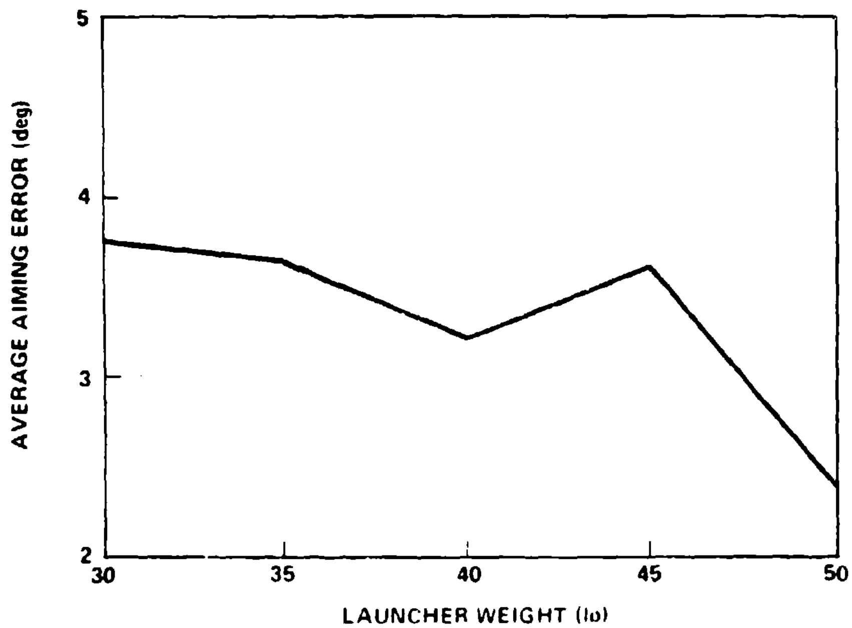

Figure 21. Aiming Error at Fire Versus Launcher Weight (All Trials)

(1) <u>Tracking</u>

a) Which launcher did you find was the easiest to track with? Why? (weight, balance, other)?

VL-3	"Weight." "Weight, balance." "Balance."
L-1	"The weight was evenly distributed also it was comfortable."
M-5	"Good even weight." "Weight and balance." "Weight and balance." "Easiest to track." "Weight was just right according to my weight and strength."
H-1	"Weight and Balance."
VH-0	

b) Which launcher did you find was the most difficult to track with? Why?

VL-4	"Can't hold it on target in the wind." "If the wind is blowing you can't hold it still." "Hard to track in windy weather, etc."
L-0	
M-1	"Tail heavy."
H-0	
VH-4	"Too heavy." "Too heavy." "Because the weight did not seem to be distributed very well." "Too heavy."
VL and VH-1	"If the wind was blowing the VL was hard to keep on target and it was unevenly balanced. The VH was too heavy to handle and superelevate."

(2) <u>Uncage-Lead-Superelevate-Fire</u>

a) Which launcher was easiest to uncage, lead, superelevate, and fire? Why?

VL-3	"Because it was lighter and easier to maneuver." "The light weight made it easier to do the firing sequence, but it was unsteady." "Cause it was very light."
L-2	"It wasn't too light or too heavy." "Less weight."

M-4 "Good even weight." "Balance and Weight." "Balance." "Medium was ideal in every aspect in my opinion."

VL, L, M&H-1 "Once the launcher was shouldered the weight did not bother me much with the exception of VH for reasons explained above in No. 4." ("because the weight did not seem to be distributed very well.")

b) Which launcher was the most difficult to uncage, lead, superelevate, and fire? Why?

VL-0

L-0

M-1 "Tail heavy."

H-0

VH-9 "To hard to superelevate." "Couldn't balance it." "Weight and balance. If you have to raise it 65 degrees it gets very difficult." "Because of the heavy weight." "It was too heavy." "Too much weight for a shoulder used weapon." "It was too heavy?" "Because it was heavy and hard to maneuver." "Reason explained in No. 4." ("because the weight did not seem to be distributed very well.")

(3) General Handling. For general usage, excluding carrying, which launcher do you prefer for engagement? Why?

VL-2 "Easy tracking and maneuvering." "Because of its light weight."

L-0

M-7 "Good even weight." "It is balanced better and is not to heavy." "The M seems to be well balanced." "It seemed like it was the best all round launcher as far as weight and firing." "The balance and weight were best." "Medium was ideal in every respect in my opinion." "Because the weight was distributed very well."

H-1 "It wasn't too heavy or too light."

(4) If you have any comments relating to usage of the different launchers, please record here.

M - "M" would be just enough weight to steady tracking.

(5) How much do you think the launchers weighed?

	10	15	20	25	28	30	33	35	40	45	45-50	50
VL	1	1	4	1		3						
L			2	4		1		3				
M					1	5			4			
H							1	1	4	4		
VH										2	1	7

9. Analysis

a. Statistical Analysis of Aiming Error at Uncage*

The arrangement of the test was that of a factorial design with four factors and with missing data. The factors were launcher weight at 5 levels, angular rate at 4 levels, 10 gunners, and 2 replicates. Thus, there should have been (5)(4)(10)(2) = 400 values for the radial aiming error at the time of uncage. However, because of missing values, there were only 349 values. A listing of the values is given in Annex H.

The primary factor of interest was launcher weight; however, it was thought that angular rate would also be important. There were 20 groups defined by the combinations of the weights and rates; each group contained from 14 to 20 values. A plot of the data in each group is shown in Figure 22. For each group, the sample average and sample variance were calculated by following: For n values, $R_{1,k}$, $R_{2,k}$, . . ., $R_{n,k}$ in the kth group the sample average was found by

$$\bar{R}_k = \frac{1}{n} \sum_{i=1}^{n} R_{i,k} \quad ,$$

and the sample variance by

$$s_k^2 = \frac{1}{n-1} \sum_{i=1}^{n} \left(R_{i,k} - \bar{R}_k\right)^2 \quad .$$

The sample averages and variances for the 20 groups are shown in Table VII. Because of the apparently wide range in the sample variances, Bartlett's test for homogeneity of variances was applied [1]. The significance level of the test was set to $\alpha = 0.05$. The test statistic was 57.68 which was larger than the critical value of 30.14. Thus, it was concluded that the variances were not homogeneous.

To approach equality of variances, the square root transformation was applied to each radial aiming error. The sample averages and variances of the transformed data are shown in Table VIII. Bartlett's test for homogeneity of variances was again performed with the significance level $\alpha = 0.05$. The test statistic was 28.56 which was less than

*The statistical analyses were prepared by N. R. Rich, Systems Evaluation, Aeroballistics Directorate, Directorate for Research, Development, Engineering and Missile Systems Laboratory, U.S. Army Missile Command.

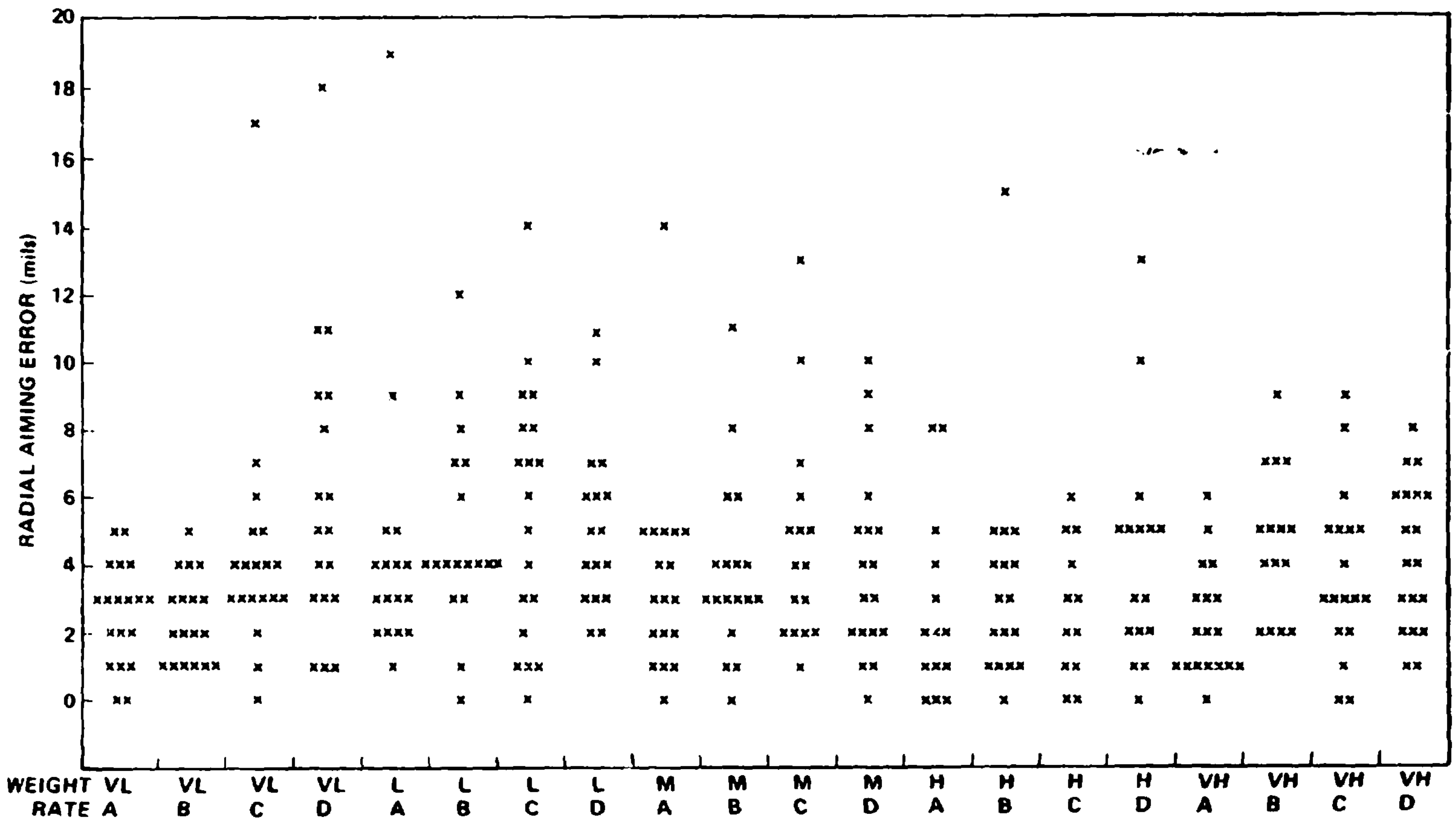

Figure 22. Radial Aiming Error Plot

Table VII. Radial Aiming Error Statistics

Weight	Rate	Number of Values	Sample Average (mils)	Sample Variance ($mils^2$)	Sample Standard Deviation (mils)
VL	A	19	2.58	2.26	1.50
	B	18	2.39	1.66	1.29
	C	20	4.25	11.46	3.39
	D	18	6.00	19.29	4.39
L	A	17	4.41	17.38	4.17
	B	18	4.89	8.22	2.87
	C	19	5.53	14.15	3.76
	D	17	5.18	6.53	2.56
M	A	18	3.61	9.43	3.07
	B	18	3.83	6.85	2.62
	C	16	4.56	10.26	3.20
	D	18	4.00	8.00	2.83
H	A	15	3.27	12.64	3.56
	B	18	3.28	11.15	3.34
	C	14	3.29	9.76	3.12
	D	16	4.25	11.53	3.40
VH	A	18	2.28	2.68	1.64
	B	15	4.67	4.67	2.16
	C	18	3.72	5.98	2.44
	D	19	4.26	4.65	2.16

the critical value of 30.14. Thus, there was insufficient evidence to conclude that the variances were not equal and the decision was made to use the transformed data.

To investigate the effect of the factors upon the square root of the radial aiming error, an analysis of variance was performed. The factors included in the analysis were weight, rate, the interaction of weight by rate, gunner, and replication. The interaction of the gunner or the replicate with any factor was considered as part of the random error. The analysis of variance is presented in Table IX. Only the weight and the rate tested as having had a significant effect upon the square root of radial aiming error ($\alpha = 0.05$). The weight by rate interaction, the gunner, and the replicate were then grouped together to test whether they could all be dropped from the prediction model. With a significance level of 0.05, there was insufficient evidence to conclude that these three factors taken together had had a significant effect upon the square root of the radial aiming error. Thus, the weight and the rate appear to have been the important contributing factors.

Table VIII. Statistics of the Square Root of Radial Aiming Error

Weight	Rate	Number of Values	Sample Average ($\sqrt{\text{mils}}$)	Sample Variance (mils)	Sample Standard Deviation ($\sqrt{\text{mils}}$)
VL	A	19	1.48	0.41	0.64
	B	18	1.49	0.18	0.42
	C	20	1.92	0.57	0.76
	D	18	2.29	0.79	0.89
L	A	17	1.97	0.58	0.76
	B	18	2.08	0.58	0.76
	C	19	2.16	0.90	0.95
	D	17	2.23	0.30	0.55
M	A	18	1.74	0.61	0.78
	B	18	1.82	0.53	0.73
	C	16	2.03	0.48	0.69
	D	18	1.85	0.62	0.79
H	A	15	1.49	1.13	1.06
	B	18	1.63	0.67	0.82
	C	14	1.58	0.86	0.93
	D	16	1.88	0.76	0.87
VH	A	18	1.40	0.35	0.59
	B	15	2.10	0.26	0.51
	C	18	1.76	0.66	0.81
	D	19	1.99	0.32	0.56

The analysis of variance procedure is based upon an assumption of normally distributed noise. The residuals (actual square roots of the radial aiming error minus the predicted values) were tested for normality by the Kolmogorov-Smirnov test [2]. The significance level of the test was set to $\alpha = 0.05$. The test statistic was 0.053 which was less than the critical value of 0.073. Thus, normality was assumed to hold.

There was recognition of the danger that the results obtained using the transformed data might not be the same as those obtained using the original data. To stabilize the variances without using the square root transformation, each radial aiming error in group k, defined by values of weight and rate, was divided by the square root of s_k^2, the estimated variance for the group. The adjusted data were then used in an analysis of variance and the same general results were obtained; the weight and the rate appeared to be the only important factors. However, normality of the residuals was rejected. Thus, the analysis involving the square root of the radial aiming error was considered more statistically valid. Nevertheless, it was comforting to find agreement from both methods.

Table IX. Analysis of Variance Using Square Root of Radial Aiming Error

Source	Degrees of Freedom	Sum of Squares	Mean Square	Test Statistic F	Critical Value of F for $\alpha = 0.05$
Weight	4	7.6276	1.907	3.35	2.40
Rate	3	8.6425	2.881	5.06	2.63
Weight by Rate	12	7.4083	0.617	1.08	1.79
Gunner	9	5.5685	0.619	1.09	1.91
Replicates	1	0.9553	0.955	1.68	3.87
Error	319	181.5385	0.569		
Total	348	211.7448			
Weight	4	7.6276	1.907		
Rate	3	8.6425	2.881		
Others Listed Above	22	13.9321	0.633	1.11	1.58
Error	319	181.5385	0.569		
Total	398	211.7448			

The group averages of the square root of the radial aiming error and the values predicted from the model are presented in Table X. If the weight, W, is considered as a quantitative variable equal to 30, 35, 40, 45, and 50 pounds for the VL, L, M, H, and VH launchers, respectively, the prediction equation for Y, the square root of the radial aiming error, must be at least third degree in W. For an approximate check of whether this result for the square root would be valid for the radial aiming error itself, a prediction equation involving the main effects for angular rate and a polynomial in weight was fitted to the unadjusted and untransformed radial aiming errors. It must be noted that the assumptions of uniform variance and normal noise probably were not met in this case. Nevertheless, the results from the radial aiming error agreed, reassuringly, with those from the square root data. The prediction error for the radial aiming error increased significanctly when the prediction equation was not at least cubic in weight. Incidentally, in each model, the predicted mean increased monotonically with increasing angular rate.

Table X. Square Root of Radial Aiming Error

Rate		Weight				
		VL	L	M	H	VH
A	Sample Average	1.479	1.966	1.742	1.489	1.396
	Model Estimate	1.566	1.874	1.626	1.415	1.567
	Difference	-0.087	0.092	0.116	0.074	-0.171
B	Sample Average	1.490	2.083	1.825	1.627	2.103
	Model Estimate	1.771	2.079	1.831	1.620	1.772
	Difference	-0.281	0.004	-0.006	0.007	0.331
C	Sample Average	1.925	2.161	2.028	1.578	1.762
	Model Estimate	1.852	2.160	1.912	1.701	1.853
	Difference	0.073	0.001	0.116	-0.197	-0.091
D	Sample Average	2.293	2.231	1.848	1.881	1.991
	Model Estimate	2.002	2.310	2.062	1.851	2.003
	Difference	0.091	-0.097	-0.214	0.030	-0.012

To summarize the primary point of interest, the radial aiming error does not vary linearly with launcher weight. For a fixed angular rate, the predicted value is highest for the light (35 pound) launcher and lowest for the heavy (45 pound) launcher.

b. Analysis of Time from Uncage to Fire

An experiment was designed to study the effects of launcher weight upon the time from uncage to fire. Each of two gunners simulated two firings for each combination of the five launcher weights and the four angular rates. However, because of missing data, there were only 73 values of uncage-to-fire time, which was measured as the number of frames from depression of the uncage bar to activation of the fire trigger. The data are given in Annex I.

An analysis of variance was performed with the following factors: (1) the interaction between weight and rate and (2) the main effects of weight, rate, gunner, and replicate. With a significance level of .10, none of the factors appeared to have had a significant effect upon the time from uncage to fire. Furthermore, when all the factors were taken together, there was insufficient evidence to indicate that the entire set of factors would contribute any information on the time between uncage and fire. In particular, either the uncage-to-fire time is not affected by the launcher weight or the sample size was too small to allow the detection of the dependence.

c. Analysis of Aiming Error at Fire

A study was made of the dependence of the radial aiming error at the time of fire upon launcher weight. For each combination of the five launcher weights and the four angular rates, each of two gunners simulated two firings. Of the 80 possible results two were discounted because of procedural errors on the part of the test subjects and 19 values were missing because of equipment and acquisition problems. Thus, there were 59 data points. The data are shown in Annex I.

The interaction between launcher weight and angular rate and the main effects of weight, rate, gunner, and replicate were the factors studied in an analysis of variance. With a significance level of $\alpha = 0.10$, there was no evidence that any or all of the factors significantly affected the aiming error at fire. In particular, the aiming error at fire did not appear to vary with launcher weight. However, it is possible that a larger sample size could lead to the detection of differences in aiming error at fire caused by differences in launcher weight.

10. Discussion

a. Aiming Error at Uncage

Aiming error at uncage increased with higher tracking rates (not an unexpected result). Under the test conditions, aiming error at uncage did not vary linearly with launcher weight. Increasing launcher weight (within the range of weights investigated) does not systematically increase radial aiming error at uncage.

It was seen that, when averaged over the four rates, the mean radial aiming error was highest for the 35-pound launcher. Peaking of mean aiming error with this weight launcher cannot be explained. Upon disclosure of this result, it appeared that a plausible and measurable explanation might have been a possible shift in the 35-pound launcher ballast. A recheck of all launchers disclosed the 35-pound launcher (as well as the other launchers) to be properly balanced; therefore, this possibility was discarded.

It may be speculated that the pronounced peak at 35 pounds (Figure 18) is caused not by poor performance with that launcher weight, but by outstanding performance with the 30-pound launcher which most closely resembles the weight of the current REDEYE launcher and with which the test subjects had received considerable training before the test. Another speculation might take the form of noting that the 30-pound launcher was located at the end of the launcher line and the test subjects may not have experienced any confinement effects; however, no adverse comments were received from the test subjects in this regard and it is felt that sufficient interlauncher spacing was allocated for gunners and observers. As noted previously, these are merely speculations.

In 1964, Gschwind [3] measured root mean square tracking error as a function of launcher weight (5, 10, 15, 20, 25, and 33 pounds). That task consisted of 10-second tracking periods against 1/3 degree per second target from standing, kneeling, sitting and prone positions. Results of the standing trials for that test, shown in Figure 23, indicate increased tracking error with increasing launcher weight. Mean radial aiming error versus launcher weight for the "A" rate of the current study (approximately 1/2 degree/second) is shown in Figure 24. If the general shapes of the two curves are considered, it might not be unreasonable to conclude (1) for launcher weights to approximately 35 pounds, increased weapon weight is accompanied by increases in aiming error, and (2) for launcher weights above approximately 35 pounds, increased weapon weight is accompanied by decreases in aiming error to some maximum weight (approximately 45 or 50 pounds as shown in Figure 18).

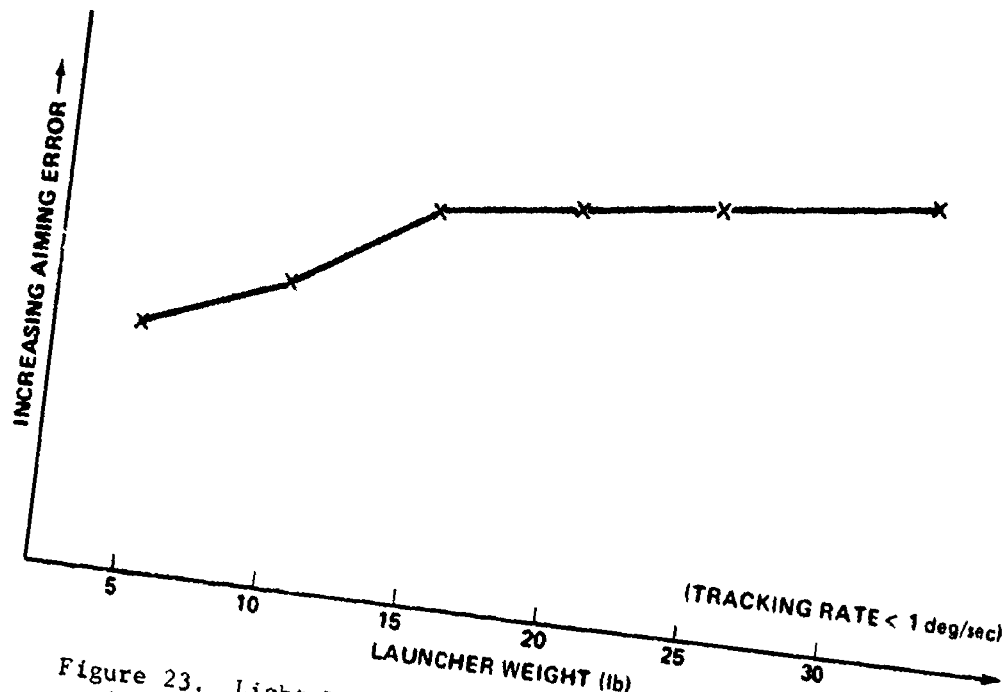

Figure 23. Light Launchers-Aiming Error Trend as a Function of Launcher Weight

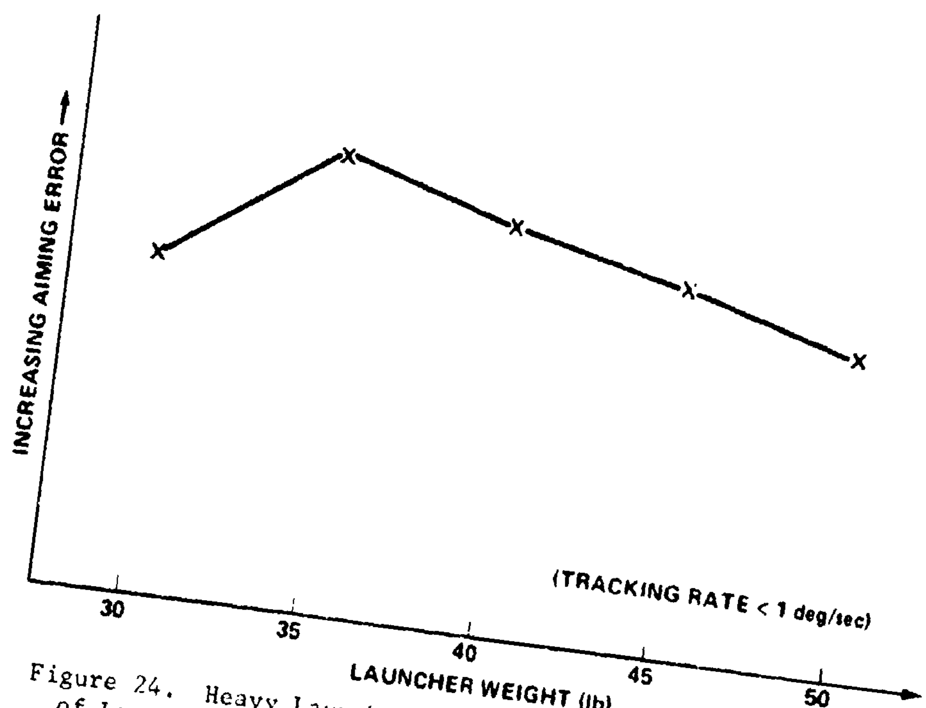

Figure 24. Heavy Launchers-Aiming Error Trend as a Function of Launcher Weight

The following is offered as a possible explanation of the high radial aiming error at 35 pounds in terms of conditions over which weight or inertial effects predominate (providing the heavier launchers are balanced at the shoulder on suitable padding and targets are moving along a predictable smooth path).

1) For launchers to approximately 35 pounds - The burden of increased weight apparently increases aiming error.

2) For launchers above approximately 35 pounds - Aiming error is reduced possibly because stability and oscillation damping benefits of the additional weight overcome the effects of effort required to handle those weights.

3) At some point around 45 to 50 pounds (or possibly beyond) - The beneficial inertial effects are not sufficient to overcome the effort required to merely handle those heavy weights and aiming error levels out and starts to increase again.

b. <u>Time from Uncage to Fire</u>

Contrary to expectations, time from uncage to fire (Figure 20) did not increase as a function of increased launcher weight. It had been felt that the abrupt launcher maneuver at the heavier weights would be somewhat more difficult to perform than at the lighter weights; however, the mean times for this task for launcher weights above and below 40 pounds were the same.

The mean times for the five weights were felt to be short, varying from approximately 1-1/3 to 1-1/2 seconds. This may have been due to (1) absence of a seeker tone and (2) the "dry-firing" method used for the test. During reduction of these film data (as well as the tape data on aiming error at uncage), it was observed that transition from uncage to lead/superelevate was frequently instantaneous. It is probable that slightly more time would have been taken had monitoring of an acquisition tone change been required. Possibly, a little more time may have been devoted to settling the superelevate point on the target had live rounds been fired.

While the uncage-to-fire time data should not be considered definitive, if one is willing to accept that any additional time for acquisition confirmation at uncage and prefire settling of the launcher during a live firing would be approximately evenly distributed, the data are probably a good comparative measure of launcher weight effects. On this basis, one could conclude that time from uncage to fire is not systematically extended by increasing launcher weight within the range examined.

c. <u>Aiming Error at Fire</u>

While the mean radial aiming error at fire (Figure 21) shows a tendency to decrease with increasing launcher weight (which would corroborate results of a previous study [4] performed using the moving

target simulator where tracking accuracy, measured in terms of time-on-target, improved with increasing launcher weight), differences caused by weight were not statistically significant at the 0.10 level because of random error. The previous comments, on the effect of "dry firing" procedures relative to time from uncage to fire, are probably relevant.

While the sample size for this subtest was small and differences between launcher weights in terms of aiming error at fire were not statistically significant, it appears reasonable, because of the tendency of aiming error at fire to decrease with increasing weight, to conclude that aiming error at fire is not increased as weapon weight is increased within the weight range examined.

11. Conclusions

Under the conditions of the test, the following was concluded:

a) Aiming error at uncage increased systematically with higher tracking rates.

b) Aiming error at uncage did not vary linearly or increase monotonically with increased launcher weight.

c) Time from uncage to fire did not increase as launcher weight was increased.

d) Aiming error at fire did not increase as launcher weight was increased.

12. Recommendations

If weapon balance is not altered and the shoulder is cushioned, it is recommended that any prospective weight addition to the currently proposed REDEYE II engagement-ready configuration be evaluated on the basis of effects other than aiming error at uncage and subsequent engagement tasks. This is particularly important if any envisioned weight increase is approximately 5 pounds or more, which might have adverse effects on weapon handling, speed of emplacement, proper task sequence performance, carrying tasks which may be required, and related factors. Confidence in these recommendations, naturally, is a function of the degree to which usage of the system will conform to the test conditions (engagement conditions, profiles, tracking rates, etc.) encountered here.

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3. Gschwind, R. T., "Gunner's Aiming Errors in Antitank Weapons (U)," U.S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Maryland, February, 1964, Technical Memorandum No. TM 5-64 (Confidential).

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Annex A

SCHEDULED HIGH-PERFORMANCE AIRCRAFT FLIGHTS

MAGNETIC AZIMUTH AND HEADING

Set	Aircraft Type	Set No.	Scheduled Run No.	Quadrant	Assign Clock	Maneuver Direction	Initial Azimuth/ Maneuver Point	Final Attack Heading	Offset Distance	Offset Direction	Proceed to Orbit Station
C-10	A-4	38	1	W	10	Climb	300/10	110	1.5	Left	
L-60	A-6	18	2	W	10		290	110	0		
L-60	TA-4	15	3	E	2		050	230	0		
D-5	F-4	58	4	W	10	Dive-Right	288/5	125	1.5	Right	
C-10	A-6	41	5	E	2	Climb	054/10	225	1.5	Left	
L-5	A-7	8	6	W	10		290	110	0		
L-60	F-4	21	7	E	2		060	240	0		
L-60	A-4	13	8	E	2		050	230	0		
L-5	F-100	12	9	W	10		290	110	0		
D-5	A-7	31	10	E	1	Dive-Left	045/5	225	0 0		
L-60	A-4	74	11	W	11		310/10	110	3.0	Left	
L-5	TA-4	4	12	W	10		290	110	0		
L-60	F-100	23	13	E	3		110	290	0		
L-5	F-4	70	14	W	10		325/10	165	3.0	Right	
D-5	A-7	56	15	W	11	Dive-Right	328/5	165	1.5	Right	
D-5	F-100	36	16	W	8	Dive-Left	250/5	070	0		
L-60	TA-4	76	17	W	10		325/10	165	3.0	Right	
L-5	A-4	61	18	E	3		120/10	320	3.0	Right	
L-60	A-7	20	19	W	9		290	110	0		
L-60	A-7	19	20	E	2		045	225	0		
L-60	F-4	81	21	E	3		080/10	280	3.0	Right	
L-5	A-6	6	22	W	10		290	110	0		
L-5	F-100	71	23	E	2		065/10	225	3.0	Left	
C-10	TA-4	39	24	E	4	Climb	130/10	320	1.5	Right	
L-60	A-4	14	25	W	11		345	165	0		

MAGNETIC AZIMUTH AND HEADING

Set	Aircraft Type	Set No.	Scheduled Run No.	Quadrant	Assign Clock	Maneuver Direction	Initial Azimuth/ Maneuver Point	Final Attack Heading	Offset Distance	Offset Direction	Proceed to Orbit Station
L-5	A-6	5	26	E	1		045	225	0		
D-5	TA-4	28	27	W	10	Dive-Right	305/5	125	0		
D-5	A-7	32	28	W	8	Dive-Right	250/5	070	0		
D-5	A-4	49	29	E	2	Dive-Right	083/5	280	1.5	Right	
C-60	F-4	22	30	W	10		290	110	0		
D-5	A-4	50	31	W	9	Dive-Left	268/5	070	1.5	Left	
D-5	TA-4	27	32	E	5	Dive-Right	140/5	320	0		
D-5	A-7	55	33	E	3	Dive-Right	083/5	280	1.5	Right	
D-5	F-100	60	34	W	9	Dive-Right	268/5	070	1.5	Left	
D-5	TA-4	52	35	W	11	Dive-Left	310/5	110	1.5	Left	
D-5	A-6	30	36	W	8	Dive-Left	250/5	070	0		
L-5	F-4	9	37	E	4		110	290	0		
L-60	F-100	83	38	E	2		065/10	225	3.0	Left	
L-60	F-4	82	39	W	11		310/10	150	3.0	Right	
D-5	A-6	53	40	E	2	Dive-Right	063/5	225	1.5	Left	
C-10	A-4	37	41	E	3	Climb	090/10	280	1.5	Right	
L-5	TA-4	3	42	E	2		070	250	0		
L-60	F-100	24	43	W	10		305	125	0		
C-10	A-7	44	44	W	10	Climb	300/10	110	1.5	Left	
L-60	A-6	77	45	E	4		105/10	265	3.0	Left	
L-60	A-7	79	46	E	3		080/10	280	3.0	Right	
L-5	F-4	69	47	E	3		080/10	280	3.0	Right	
L-5	A-4	2	48	W	8		250	070	0		
L-5	A-7	68	49	W	9		280/10	125	3.0	Right	

MAGNETIC AZIMUTH AND HEADING

Set	Aircraft Type	Set No.	Scheduled Run No.	Quadrant	Assign Clock	Maneuver Direction	Initial Azimuth/ Maneuver Point	Final Attack Heading	Offset Distance	Offset Direction	Proceed to Orbit Station
D-5	F-100	35	50	E	3	Dive-Right	100/5	280	0		
D-5	A-6	54	51	W	9	Dive-Right	268/5	070	1.5	Left	
L-5	TA-4	64	52	W	11		325/10	165	3.0	Right	
L-5	A-7	7	53	E	2		060	240	0		
C-10	F-4	46	54	W	10	Climb	300/10	110	1.5	Left	
L-60	F-100	84	55	W	9		270/10	070	3.0	Left	
L-5	F-100	11	56	E	4		120	300	0		
L-60	A-6	17	57	E	22		070	250	0		
L-60	A-4	73	58	E	3		100/10	300	3.0	Right	
L-60	TA-4	75	59	E	3		100/10	260	3.0	Left	
L-5	A-6	66	60	W	10		310/10	110	3.0	Right	
C-10	F-4	45	61	E	4	Climb	130/10	320	1.5	Right	
D-5	A-4	26	62	W	10	Dive-Left	285/5	105	0		
C-10	A-7	43	63	E	3	Climb	090/10	280	1.5	Right	
L-5	A-6	65	64	E	3		105/10	265	3.0	Left	
D-5	F-4	34	65	W	10	Dive-Left	290/5	110	0		
D-5	A-4	25	66	E	5	Dive-Right	140/5	320	0		
C-10	TA-4	40	67	W	10	Climb	300/10	110	1.5	Left	
C-10	F-100	48	68	W	9	Climb	259/10	070	1.5	Left	
D-5	F-4	37	69	E	4	Dive-Left	103/5	265	1.5	Left	
C-10	A-6	42	70	W	9	Climb	259/10	070	1.5	Left	
L-5	A-4	62	71	W	10		270/10	070	3.0	Left	
L-5	TA-4	63	72	E	4		105/10	265	3.0	Left	
L-60	A-7	80	73	W	10		280/10	125	3.0	Right	
C-10	F-100	47	74	E	2	Climb	054/10	225	1.5	Left	
L-5	F-100	72	75	W	9		270/10	070	3.0	Left	
D-5	A-6	29	76	E	2	Dive-Left	045/5	225	0		

MAGNETIC AZIMUTH AND HEADING

Set	Aircraft Type	Set No.	Scheduled Run No.	Quadrant	Assign Clock	Maneuver Direction	Initial Azimuth/ Maneuver Point	Final Attack Heading	Offset Distance	Offset Direction	Proceed	to Orbit Station
L-5	A-4	1	77	E	3		080	260	0			
L-5	A-7	67	78	E	2		080/10	280	3.0	Right		
L-60	A-6	78	79	W	11		325/10	165	3.0	Right		
D-5	F-100	59	80	E	2	Dive-Right	063/5	225	1.5	Left		
I-60	TA-4	16	81	W	11		345	165	0			
L-5	F-4	10	82	W	10		305	125	0			
D-5	TA-4	51	83	E	4	Dive-Left	103/5	265	1.5	Left		
D-5	F-4	33	84	E	3	Dive-Left	258/5	265	0			

Annex B

DERIVATION OF ANGULAR TRACKING RATES AVAILABLE FROM LADS II/AMTOC II TARGETS

The following parameters with associated drawings were used in the derivations of equations for angular tracking rates for three flight profiles:

- G - Gunner's Position
- V - Velocity of Aircraft
- V_T - Tangential Component of Velocity (Perpendicular to Gunner's Line-of-Sight
- R - Slant Range
- L - Slant Range at Crossover
- X - Downrange Distance from Crossover
- Y - Aircraft Altitude
- Z - Offset Distance (Gunner to Crossover)

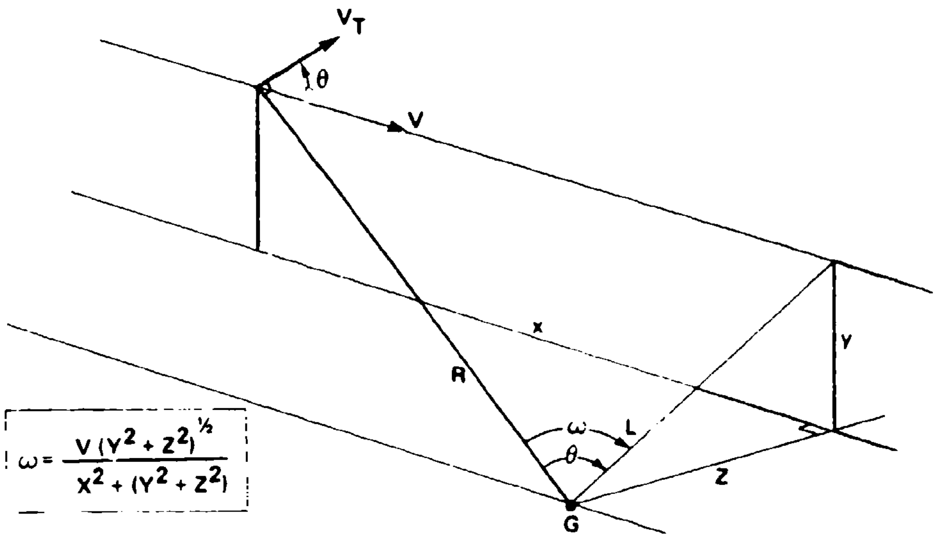

Figure B-1. Level Flight With/Without Offset

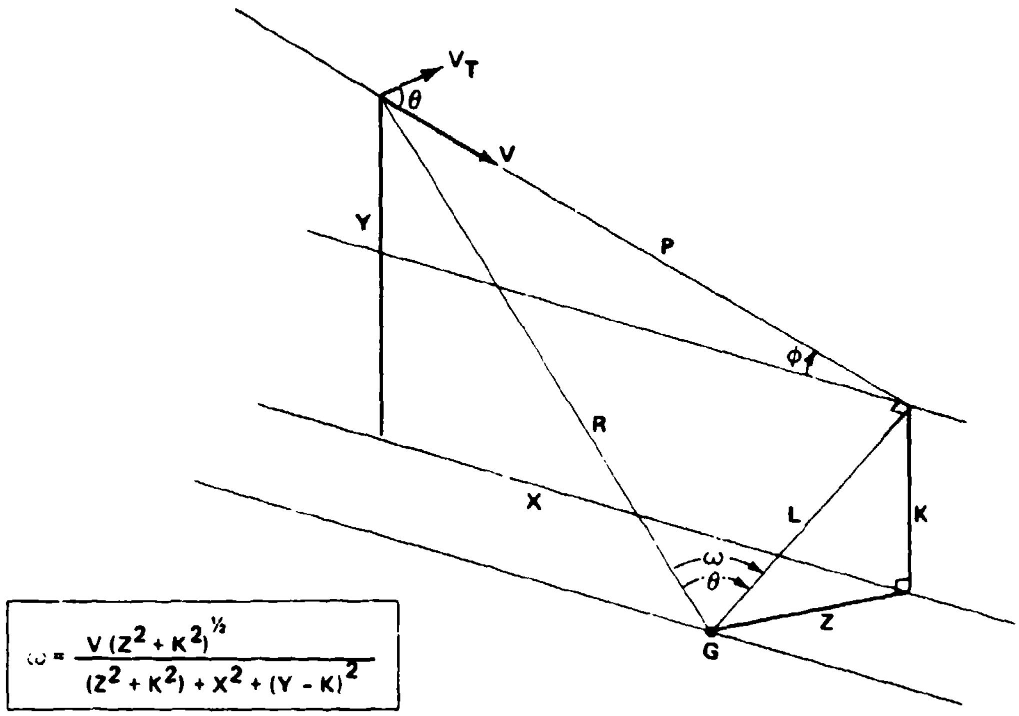

Figure B-2. Diving Flight with Offset

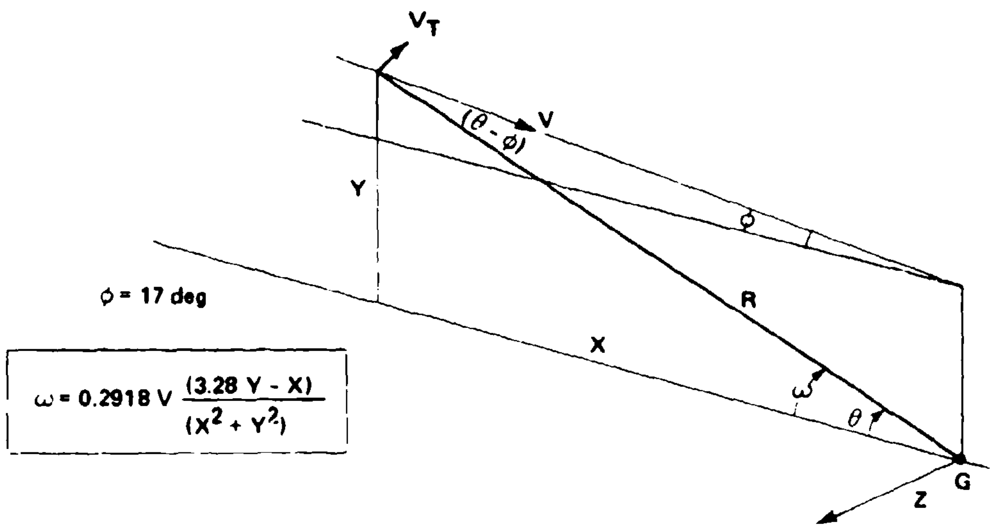

Figure B-3. Diving Flight - Zero Offset

Annex C

TEST DEVICES, INSTRUMENTATION AND SUPPLIES

	Quantity
Launchers, Recording Equipment and Related	
Fixed Weight Modified Launchers with TV Camera Fixtures	5
TV Camera Ensemble, Sony AV3400/AVC 3400	5
Video Tape Rolls, Sony V30H	32
Battery Pack, Sony BP20	12
Battery, automotive, 12V, Penneys	3
Switch box, Video Recorder Control	5
Crates and Launcher Cradles, Fixed-weight Launchers	5
Extension Cabling	As Required
Variable Weight Modified Launcher with 16mm Camera Fixture	1
Gun Camera, 16mm Motion Picture	1
Type U 16mm Film Magazines, Ektachrome MS, Type 7256, 50 ft (Kodak)	21
Launcher Weight Sets	5
Crate and Launcher Cradles	1
Crate, Launcher Weight Set	1
Tracking Rate Generator and Related	
Tracker, Manually Operated, Viscous-Damped, Experimental	1
VOM, Triplett Model 801, Type 1	1
Scale Switch box	1
Spare Batteries, VOM, 4.5 volt	3
Spare Battery, VOM, 1.5 volt	1
Tracker Stakes	3
Sandbags	3
Set Hand Tools	1
Tracker Collar Grip (C Clamp)	1
Scope, 4X20, Swift Model 722	1
Clamps, Scope	2
Extension Cabling	As Required
Site-Installed Items	
Azimuth Stakes	12
Clock Numbers, Posterboard	12
Flight Number Board	1
Flight Numbers, Posterboard	19
Field Phone	1

	Quantity
Preprinted Forms	
Personal Inventory Data Sheets	10
Gunner Assignment Forms (sets)	6
Flight Sequence Sheets (sets)	2
Post-Test Questionaires	10
Other Miscellaneous	
Clip Boards	8
Binoculars, 10 X 50	1
String, 125 ft	1
Marker Card Clips	48
Tablets, Lined	12
Pencils	48
Storage Containers	As Required

Annex D
FLIGHT SEQUENCE SHEETS

FLIGHT SEQUENCE SHEET

Flight #	Rate	mv	Quad/ Clock	Init Az Man. pt.	Profile	Fixed Wt. Lchr Assignments VL	L	M	H	VH	Var Wt. Lchr	Time	Notes
1	D	[illegible]	W-10	300/ 10	C10/1.5 L	1	2	3	4	5	6		
2	F	[illegible]	W-10	290	L60	1	2	3	4	5	6		
3	C	[illegible]	E-2	050	L60	1	2	3	4	5	6		
4	D	[illegible]	W-10	288/ 5	D5/1.5R	1	2	3	4	5	6		
5	D	[illegible]	E-2	054/ 10	C10/1.5L	6	7	8	9	10	1		
6	A	[illegible]	W-10	290	L5	6	7	8	9	10	1		
7	B	[illegible]	E-2	060	L60	6	7	8	9	10	1		
8	C	[illegible]	E-2	050	L60	6	7	8	9	10	1		

FLIGHT SEQUENCE SHEET

Flight #	Rate	inv	Quad/ Clock	Init Az. Man. pt.	Profile	Fixed Wt. Lchr Assignments VL	L	M	E	VH	Var Wt. Lchr	Time	Notes
9	A	33	W-10	290	L5	5	1	2	3	4	6		
10	A	[illegible]	E-1	045/ 5	D5	5	1	2	3	4	6		
11	B	[illegible]	W-11	310/ 10	L60/3L	5	1	2	3	4	6		
12	A	[illegible]	W-10	290	L5	10	6	7	8	9	1		
13	B	[illegible]	E-3	110	L60	10	6	7	8	9	1		
14	C	50	W-10	325/ 10	L5/3R	10	6	7	8	9	1		
15	D	[illegible]	W-11	328/ 5	D5/1.5R	10	6	7	8	9	1		
16	A	[illegible]	W-8	250/ 5	D5	10	6	7	8	9	1		

FLIGHT SEQUENCE SHEET

Flight #	Rate	mv	Quad/ Clock	Init Az Man. pt.	Profile	Fixed Wt. Lchr Assignments VL	L	M	H	VH	Var Wt. Lchr	Time	Notes
17	B	22	W-10	325/ 10	L60/3R	2	3	4	5	1	6		
18	C	[illegible]	E-3	120/ 10	L5/3R	2	3	4	5	1	6		
13	B	[illegible]	W-9	290	L60	2	3	4	5	1	6		
20	C	42	E-2	045	L60	7	8	9	10	6	1		
21	B	22	E-3	080/ 10	L60/3R	7	8	9	10	6	1		
22	A	33	W-10	290	L5	7	8	9	10	6	1		
23	C	[illegible]	E-2	065/ 10	L5/3L	7	8	9	10	6	1		
24	D	[illegible]	E-4	130/ 10	C10/1.5R	7	8	9	10	6	1		

FLIGHT SEQUENCE SHEET

Flight #	Rate	mv	Quad/ Clock	Init Az Man. pt.	Profile	Fixed Wt. Lchr Assignments VL	L	M	H	VH	Var Wt. Lchr	Time	Notes
25	B	[illegible]	W-11	345	L60	4	5	1	2	3	6		
26	A	[illegible]	E-1	045	L5	4	5	1	2	3	6		
27	A	35	W-10	305/ 5	D5	4	5	1	2	3	6		
28	A	35	W-8	250/ 5	D5	9	10	6	7	8	1		
29	D	70	E-2	083/ 5	D5/1. 5R	9	10	6	7	8	1		
30	C	40	W-10	290	L60	9	10	6	7	8	1		
31	D	70	W-9	268/ 5	D5/1. 5L	9	10	6	7	8	1		
32	A	35	E-5	140/ 5	D5	9	10	6	7	8	1		

FLIGHT SEQUENCE SHEET

Flight #	Rate	mv	Quad/ Clock	Init Az Man. pt.	Profile	Fixed Wt. Lchr Assignments VL	L	M	H	VH	Var Wt. Lchr	Time	Notes
33	D	[illegible]	E-3	[illegible]83/ 5	D5/1.5R	3	4	5	1	2	6		
34	D	[illegible]	W-[illegible]	268/ 5	D5/1.5L	3	4	5	1	2	6		
35	D	[illegible]	W-11	310/ 5	D5/1.5L	8	9	10	6	7	1		
36	A	[illegible]	W-8	250/ 5	D5	8	9	10	6	7	1		
37	A	[illegible]	E-4	110	L5	8	9	10	6	7	1		
38	B	[illegible]	E-2	065/ 10	L60/3L	3	4	5	1	2	6		
39	C	59	W-11	310/ 10	L60/3R	3	4	5	1	2	6		
40	D	[illegible]	E-2	063/ 5	D5/1.5L	8	9	10	6	7	1		

FLIGHT SEQUENCE SHEET

Flight #	Rate	mv	Quad/ Clock	Init Az Man. pt.	Profile	Fixed Wt. Lchr Assignments VL	L	M	H	VH	Var Wt. Lchr	Time	Notes
41	C	42	E-3	090/ 10	C10/1.5R	3	4	5	1	2	6		
42	A	3.5	E-2	070	L5	3	4	5	1	2	6		
43	B	17	W-10	305	L60	3	4	5	1	2	6		
44	C	42	W-10	300/ 10	C10/1.5L	8	9	10	6	7	1		
45	B	22	E-4	105/ 10	L60/3L	8	9	10	6	7	1		
46	B	22	E-3	080/ 10	L60/3R	8	9	10	6	7	1		
47	C	50	E-3	080/ 10	L5/3R	8	9	10	6	7	1		
48	A	3.5	W-8	250	L5	3	4	5	1	2	6		

FLIGHT SEQUENCE SHEET

Flight #	Rate	mv	Quad/ Clock	Init Az Man. pt.	Profile	Fixed Wt. Lchr Assignments VL	L	M	H	VH	Var Wt. Lchr	Time	Notes
49	C 14	50	W-9	280/ 10	L5/3R	4	5	1	2	3	6		
50	A		E-3	100/ 5	D5								
51	D 12	70	W-9	268/ 5	D5/1.5L	4	5	1	2	3	6		
52	C 14	50	W-11	325/ 10	L5/3R	4	5	1	2	3	6		
53	A		E-2	060	L5								
54	D 13	70	W-10	300/ 10	C10/1.5L	4	5	1	2	3	6		
55	B 2	22	W-9	270/ 10	L60/3L	4	5	1	2	3	6		
56	A		E-4	120	L5								
57	C	40	E-2	070	L60	9	10	6	7	8	1		
58	B 2	22	E-3	100/ 10	L60/3R	9	10	6	7	8	1		
59	B	22	E-3	100/ 10	L60/3L	9	10	6	7	8	1		

FLIGHT SEQUENCE SHEET

Flight #	Rate	mv	Quad/ Clock	Init Az Man. pt.	Profile	Fixed Wt. Lchr Assignments VL	L	M	H	VH	Var Wt. Lchr	Time	Notes
60	C [illegible]	50	W-10	310/ 10	L5/3L	2	3	4	5	1	6		
61	D 13	70	E-4	130/ 10	C10/1.5R	2	3	4	5	1	6		
62	A 4	3.5	W-10	285/ 5	D5	2	3	4	5	1	6		
63	D 13	70	E-3	090/ 10	C10/1.5R	2	3	4	5	1	6		
64	B 2	21	E-3	105/ 10	L5/3L	7	8	9	10	6	1		
65	A 4	3.5	W-10	290/ 5	D5	2	3	4	5	1	6		
66	A 4	3.5	E-5	140/ 5	D5	7	8	9	10	6	1		
67	D 13	70	W-10	300/ 10	C10/1.5L	7	8	9	10	6	1		

FLIGHT SEQUENCE SHEET

Flight #	Rate	mv	Quad/ Clock	Init Az Man. pt.	Profile	Fixed Wt. Lchr Assignments VL	L	M	H	VH	Var Wt. Lchr	Time	Notes
68	D 13	70	W-9	259/ 10	C10/1.5L	10	6	7	8	9	1		
69	D 12	70	E-4	103/ 5	D5/1.5L	5	1	2	3	4	6		
70	D [illegible]	70	W-9	259/ 10	C10/1.5L	5	1	2	3	4	6		
71	C 14	50	W-10	270/ 10	L5/3L	5	1	2	3	4	6		
72	C 14	50	E-4	105/ 10	L5/3L	5	1	2	3	4	6		
73	B 2	22	W-10	280/ 10	L60/3R	5	1	2	3	4	6		
74	C 9	42	E-2	054/ 10	C10/1.5L	10	6	7	8	9	1		
75	B 3	21	W-9	270/ 10	L5/3L	10	6	7	8	9	1		

FLIGHT SEQUENCE SHEET

Flight #	Rate	mv	Quad/ Clock	Init Az Man. pt.	Profile	Fixed Wt. Lchr Assignments VL	L	M	H	VH	Var Wt. Lchr	Time	Notes
76	A 4	35	E-2	045/ 5	D5	1	2	3	4	5	6		
77	A	33	E-3	080	L5	1	2	3	4	5	6		
78	C	50	E-2	080/ 10	L5/3R	1	2	3	4	5	6		
79	C	50	W-11	325/ 10	L60/3R	6	7	8	9	10	1		
80	D	79	E-2	063/ 5	D5/1.5L	6	7	8	9	10	1		
81	B 3	19	W-11	345	L60	6	7	8	9	10	1		
82	A	3	W-10	305	L5	6	7	8	9	10	1		
83	B	19	E-4	103/ 5	D5/1.5L	1	2	3	4	5	6		
84	A 4	3.[illegible]	E-3	285/ 5	D5								

Annex E
TEST SUBJECT INDOCTRINATION

1. Introduction

   a) Administrative

   b) Purpose of test (general)

   c) Test plan

   d) Schedules

2. Personal Data

3. Gunner Assignments

4. Description of Test Launchers and Camera Operation

   a) Fixed weight launchers

   b) Variable weight launcher

5. On-Site Procedures

   a) Use of gunner assignment form

      1) Launcher assignment

      2) Gunner-observer rotation

      3) Inbound clock and location of stake marker

      4) Final 5-kilometer profile

   b) Target Acqusition and tracking

      1) When to initiate search ("Inbound" callout)

      2) When to shoulder the launcher

      3) Confirmation of detection

      4) When to start tracking

      5) When to start camera ("Record" callout)

   c) Engagement

      1) Meaning of "Mark" callout

      2) When to uncage, lead, superelevate, and fire ("Uncage" callout)

Preceding page blank

3) Confirming engagement; acknowledgement by test conductor

4) Maintaining track

5) When to stop tracking

d) Post Engagement

1) Photographing (or taping) flight number board

2) Turning off the recorder

3) Turning off the camera

4) Return launcher to cradles

e) Post Trial

1) Entry of flight completion time on gunner assignment form

2) Entry of remarks, if any, on gunner assignment form

6. <u>Care of Launcher</u>

a) Use of pedestal

b) Sun avoidance

c) Maintenance of boresight

7. <u>Demonstration of Typical Flight Sequences</u>

8. <u>Dry-Run Practice Sessions</u>

Practice of tasks under "On-Site Procedures"

9. <u>Use of Variable Weight Launcher (Subjects 1 and 6)</u>

10. <u>Field Practice Sessions (Helicopter)</u>

a) Test site familiarization

b) Correlation of azimuth markers with gunner assignment form

c) Initial set up, pedestal positioning, boresight, and camera load

d) Refamiliarization with precautions (fragility, sun, and boresight)

e) Practice against helicopters

f) Remedial training as required

11. <u>Field Practice Sessions (High Performance Aircraft)</u>

Approximately eight practice trials will be conducted before the first recorded trial with high performance aircraft.

Annex F

FIELD PRACTICE AND SHAKEDOWN TEST

1. Test Site Layout

   a) Determination of precise location of test with with respect to ground zero

   b) Determination of launcher locations, marking, and recording with respect to test site center

   c) Emplace launchers and cradles

   d) Emplace tracker and rate readouts; check operation

   e) Load film, tape; emplace power supplies, cabling, recorders, and TV monitor.

   f) Emplace azimuth markers (clock) and flight number board

   g) Boresight all launchers

   h) Establish communication with LADS II/AMTOC II net and timing mark generation

   i) Distribute gunner assignment forms, pencils, clipboards, etc.

   j) Locate test subjects with their respective launchers in accordance with the flight sequence sheet; adjust ballast in variable weight launcher.

2. Practice Sessions

   a) Detection, tracking, engagement, and use of gunner assignment forms

   b) Rotation of gunners and observers

   c) Launcher assignment changes

   d) Rotation of subjects 1 and 6 between fixed and variable weight launcher

   e) Secure timing of ballast change in variable weight launcher

   f) Evaluate responsiveness to "Uncage" command

   g) Remedial practice sessions as required.

3. Evaluation

   a) Operator procedure and tracker proficiency

   b) Test site/administrative procedures/communication

c) TV Tape

1) Picture quality

2) FOV

3) Audio and video annotation methods

4) Sample data reduction

a) Facility of measuring aiming error

b) Suitability of annotation for data reduction

c) Variation of uncage points/confirmation of track rates

d) General performance

d) 16mm Film

1) Picture quality

2) FOV

3) Proper operation of annotation lights for data reduction

4) Sample data reduction

a) Facility of measuring aiming error

b) Suitability of annotation (film and lights) for data reduction

c) Variation of uncage and fire points/confirmation of track rates

d) General performance

e) Changes

As required.

Annex G

METEOROLOGICAL DATA

USA METEOROLOGICAL TEAM YUMA

Surface Meteorological Support

Page 1 of 1 Pages

Program: [illegible] Date: 22 Nov 71 Position: 15 mi East of Space Chain Elev(Ground): 310 Meters

Nr	Time (mst)	Amb Temp (~~°C~~) (°F)	Wet Bulb (~~°C~~) (°F)	Dep Wet Bulb	Rel Hum (%)	Dew Point (~~°C~~) (°F)	~~Soil Temp (°C) (°F)~~	Sky Cond	Vis	Sta Press (mbs)	Wind Dir (°T)	Wind Speed Knots				
	0830	54.5	44.5	10.0	40	32.8		CLEAR	7+	975.4	310	02	HAZE	A QUADS		
	0900	58.0	45.1	12.9	35	27.4		CLEAR	7+	976.0	310	02	HAZE	A QUADS		
	1000	64.0	47.1	16.9	24	26.3		CLEAR	10+	975.9	CALM		HAZE	13-E		
	1100	69.2	49.5	19.7	20	26.4		CLEAR	10+	975.8	160	03	HAZE	SE		
	1200	67.0	49.6	17.4	25	30.5		P. CLDY	15+	975.0	095	01	HAZE	A QUADS		
	1300	67.4	50.1	17.3	26	31.6		P. CLDY	15+	974.1	230	03	HAZE	SE		
	1400	72.3	50.3	22.0	20	27.8		P. CLDY	15+	973.9	310	04	HAZE	S		
	1500	73.8	51.7	22.1	18	27.2		P. CLDY	25	973.4	230	03	HAZE	S		
	1530	70.4	51.9	18.5	25	33.3		P. CLDY	25	973.3	260	06	HAZE	SW		

Observer: Blair Checker: Lo

SELHU-MT-Y Form 3, 1 Jun 66. Replaces STEYP-MET Forms 10 and 35 which may be used until supply is exhausted.

USA METEOROLOGICAL TEAM YUMA

Surface Meteorological Support

Page 1 of 1 Pages

Program: CAPE O'NEIL Date: 23 NOV. 1971 Position: 15 miles east of STEAE CEBIL Elev(Ground): 340 Meters

Nr	Time (mst)	Amb Temp ~~(°C)~~ (°F)	Wet Bulb ~~(°C)~~ (°F)	Dep Wet Bulb	Rel Hum (%)	Dew Point ~~(°C)~~ (°F)	~~Soil Temp (°C) (°F)~~	Sky Cond	Vis miles	Sta Press (mbs)	Wind Dir (°T)	Wind Speed kts				
	0800	52.1	43.2	8.9	47	32.6		CLEAR	10+	974.9	270	03	HAZE		Es	
	0900	56.3	47.9	8.4	53	39.8		CLEAR	15+	975.0	310	03	HAZE			
	1000	61.1	51.1	10.0	49	42.2		CLEAR	15+	975.0	280	04	HAZE			
	1100	65.9	53.2	12.7	42	42.4		CLEAR	15+	975.7	CALM		HAZE			
	1200	70.9	54.1	16.8	31	38.6		CLEAR	15+	974.9	295	03	HAZE			
	1300	72.8	55.2	17.6	30	40.2		CLEAR	15+	974.2	270	04	HAZE			
	1400	72.0	54.8	17.2	31	40.2		CLEAR	15+	974.0	300	04	HAZE			
	1500	70.6	54.5	16.1	33	40.7		CLEAR	15+	973.1	290	04	HAZE			
	1530	69.5	54.0	15.5	34	40.0		CLEAR	15+	973.3	CALM		HAZE			

Observer: Blair Checker: Low

SELHU-MT-Y Form 3, 1 Jun 66. Replaces STEYP-MET Forms 10 and 35 which may be used until supply is exhausted.

USA METEOROLOGICAL TEAM YUMA

Surface Meteorological Support

Page 1 of 1 Pages

Program: [illegible] Date: 24 Nov 71 Position: 15 Mi East [illegible] Elev(Ground): [illegible] Meters

Nr	Time (mst)	Amb Temp (°F)	Wet Bulb (°C) (°F)	Dep Wet Bulb	Rel Hum (%)	Dew Point (°C) (°F)	Soil temp (°C) (°F)	Sky Cond	Vis	Sta Press (mbs)	Wind Dir (°T)	Wind Speed (Kts)				
	[illegible]	56.5	[illegible]	7.7	46	36.3		CLEAR	15+	975.[illegible]	290	06	HAZE		G, S	
	0900	58.2	47.9	10.3	45	37.0		CLEAR	15+	974.1	290	03	HAZE			
	1000	66.0	52.5	13.5	39	40.0		CLEAR	15+	974.9	270	04	HAZE			
	1100	[illegible]	52.8	[illegible]	39	33.5		CLEAR	15+	975.0	— CALM —		HAZE			
	1200	75.6	55.0	20.6	23	35.5		CLEAR	15+	974.8	270	01	HAZE			

Observer: [illegible] Checker: [illegible]

SELHU-MT-Y Form 3, 1 Jun 66. Replaces STEYP-MET Forms 10 and 35 which may be used until supply is exhausted.

USA METEOROLOGICAL TEAM YUMA

Surface Meteorological Support

Page 1 of 1 Pages

Program: O'NEIL   Date: 29 NOV 71   Position: 15 MI EAST [illegible]   Elev(Ground): 310 Meters

Nr	Time (mst)	Air Temp ~~(°C)~~ (°F)	Wet Bulb ~~(°C)~~ (°F)	Dep Wet Bulb	Rel Hum (%)	Dew Point ~~(°C)~~ (°F)	Soil Temp (°C) (°F)	Sky Cond	Vis	Sta Press (mbs)	Wind Dir (°T)	Wind Speed (KTS)	REMARKS
	0730	64.5	54.4	10.1	51	46.2		O-CAST	10+		270	08	HAZE
	1000	65.5	54.3	11.2	47	45.0		O-CAST	10+		270	07	HAZE
	1100	65.6	54.5	11.1	48	45.7		O-CAST	10+		280	09	HAZE & DUST
	1200	68.6	55.2	13.4	41	44.0		BROKEN	15+		280	07	HAZE & DUST TO N
	1300	66.6	55.9	10.7	50	47.7		O-CAST	15+		250	07	
	1400	64.7	54.4	10.3	50	46.0		O-CAST	15+		270	05	
	1500												
													LOW O-CAST
													ALL DAY

Observer: BLAIRS BEIDERBECKE   Checker: ______

SELHU-MG-Y Form 3, 1 Jun 66. Replaces STEYP-MET Forms 10 and 35 which may be used until supply is exhausted.

USA METEOROLOGICAL TEAM YUMA

Surface Meteorological Support

Page 1 of 1 Pages

Program: CAPT O'NEIL Date: 30 NOVEMBER 71 Position: 15 MI. EAST OF STONE CABIN Elev(Ground): 340 Meters

Nr	Time (mst)	Amb Temp (°F)	Wet Bulb (°F)	Dep Wet Bulb	Rel Hum (%)	Dew Point (°F)	~~Soil Temp (°C) (°F)~~	Sky Cond	Vis	Sta Press (mbs)	Wind Dir (°T)	Wind Speed (KNTS)				
	0835	50.7	43.4	7.3	55	35.1		O'CAST	10+		CALM		HAZE			
	0900	49.9	42.9	7.0	56	34.9		O'CAST	10+		CALM		HAZE			
	1000	55.6	48.0	7.6	57	40.7		O'CAST	10+		CALM		HAZE			
	1100	59.2	48.9	10.3	47	39.0		O'CAST	15+		035	02	HAZE			
	1200	64.8	50.9	13.9	36	37.6		O'CAST	15+	968.0	200	03	HAZE			
	1300	63.9	51.1	12.8	40	39.2		BROKEN	15+	967.3	240	02	HAZE			
	1400	64.1	51.2	12.9	39	39.1		BROKEN	15+	967.0	CALM		HAZE			
	1500	60.9	50.0	12.9	41	37.4		BROKEN	10+	966.9	CALM		HAZE			

Observer: BEIDERBECKE & BLAIR Checker: Lo

SELHU-MT-Y Form 3, 1 Jun 66. Replaces STEYP-MET Forms 10 and 35 which may be used until supply is exhausted.

Annex H
RADIAL AIMING ERROR AT UNCAGE (MILS)

Weight	VL				L				M				H				VH			
Gunner \ Rate	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
1	4 4	5 4	2 4	6 9	1 2	9 7	1 3	5 11	5	3 4	2 13	5 1	4 [illegible]	2 1	4 12	0 13	3 1	5	3 2	5 6
2	4 [illegible]	3 3	5 4	3 4	5 4	4 3	8	10 2	3 1	0 3		2 10	0 1	15. 1	1		1	2	9	6 3
3	2 5	1 3	1 4	5 6	2 4	4 0	1 2	4 7	2 4	1 3	5 4	3 5	1 2	1	2 3	5 5	0 3	5 4	5	4
4	3 0	4 1	4 3	1 1	3 3	12 4	5 1	7 2	0 4	1 4	4 7	6 8	0 12	5 4	1 0	1	4 1	5	3 6	4 3
5	5 3	2 1	0 4	5	2 5	4 3	6 7	4	2 5	8 6	5 10	9 2	8	5 4	6	2 5	2 3	2 7	3 3	1 3
6	3 3	2 1	6 3	3	3	4 1	8 14	4 5	3 3	3 4	1 2	2 4	2	0 3	0	10 2	1	7 7	2 0	2 2
7	2	1 3	4 17	1 18	19 4	4	10 4	3	1 2	4 2	6	2 0	3	5 1		6	1 5	2 9	0 4	7 6
8	0 1	4	3 3	11 9	9	7 4	7 0	6	14 1		3	5 1	1 5	4	5	3 2	6 4	4	1 8	2 5
9	2 3	2 1	3 7	3 4	2	4 8	7 9	6 6	5	3 3	2 3	4 3	0 2	2 3	2 3	1 5	1 2	5 4	3 5	6 8
10	1 3	2	3 5	8 11	4 3	6	9 3	3 3	5 5	11 6	4 2		8	2 1	2 5	3 5	2 1	2	5 5	1 7

Annex I
TIME FROM UNCAGE TO FIRE AND RADIAL AIMING ERRORS AT FIRE

Table I-I. Time from Uncage to Fire (Frames)*

Launcher Weight**

Tracking Rate***	VL		L		M		H		VH	
A	20	28	24	19	35	30	14	13	20	-
	20	-	29	20	19	24	-	26	21	28
B	14	16	18	39	22	20	32	23	20	15
	32	22	31	26	21	19	20	19	34	28
C	19	25	18	16	26	15	12	24	-	-
	17	18	26	27	27	17	41	21	21	22
D	13	19	14	24	40	30	-	13	34	26
	27	-	24	21	31	25	24	17	19	20

Table I-II. Aiming Error at Fire (Deg)

Launcher Weight**

Tracking Rate***	VL		L		M		H		VH	
A	3½	4	4	8	-	-	-	4½	2	-
	4	-	3	2½	3	-	-	3	1½	-
B	1	4	1½	2	3½	3½	1½	5	-	2½
	1	5	4½	-	2	3	-	4	-	1½
C	3	4	3	2	5	1	3½	3½	-	-
	-	-	3	4	2½	4	6	3	-	2
D	3	4½	4	3½	3	1	-	3	4	2½
	8	-	9½	16	4½	6	3½	12	2	3½

*16 frames/sec
**VL-30 lb, L-35 lb, M-40 lb, H-45 lb, VH-50 lb
***A-<1 deg/sec, B-1 to 4 deg/sec, C-4 to 7 deg/sec, D->7 deg/sec

Dash indicates missing data.

1st trial	2nd trial
gunner 1	gunner 1
gunner 6	gunner 6

GLOSSARY

CLOCK	Lirection from which incoming aircraft approach, based on 12 o'clock at Magnetic North.
C10/1.5	Refers to flight profile: Climb from 1000 feet at 10-kilometer downrange to 6000 feet at 5-kilometer downrange; level from 5-kilometer downrange to 1.5-kilometer offset from ground zero.
D5/0	Refers to high performance aircraft flight profile: Dive from 6000 feet at 5-kilometer downrange to 1000 feet at ground zero.
D5/1.5	Refers to high performance aircraft flight profile: Dive from 6000 feet at 5-kilometer downrange to 1000 feet at 1.5-kilometer offset from ground zero.
Initial Azimuth	Azimuth, from test site, of incoming aircraft before required maneuver.
L5/0	Refers to high performance aircraft or helicopter flight profile: Level at 500 feet to ground zero.
L5/3	Refers to high performance aircraft or helicopter flight profile: Level at 500-foot to 3-kilometer offset from ground zero.
L60/0	Refers to high performance aircraft flight profile: Level at 6000 feet to ground zero.
L60/3	Refers to high performance aircraft flight profile: Level at 6000 feet to 3-kilometer offset from ground zero.
L10/0	Refers to helicopter flight profile: Level at 1000 feet to ground zero.
L10/3	Refers to helicopter flight profile: Level at 1000 feet to 3-kilometer from ground zero.
Maneuver Direction	Direction of aircraft maneuver as seen by pilot.
Maneuver Point	Range from test site at which maneuver is initiated.

Offset Distance	Distance of point (over which aircraft will fly) measured perpendicular from aircraft flight path to ground zero.
Offset Direction	Direction of offset from ground zero at crossover as seen from test site.
QUAD	Quadrant (East or West) of aircraft approach as seen from test site.
SDP	System Development Plan.
SET	Flight Profile Coding used by MCDEC, not used for tracking test.